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ABSTRACT

The first Standard Grade courses have been in place in Scotland for almost ten years. This document reports on a study with the following goals: (1) to describe the actual mathematical competencies of pupils gaining grades 3, 4, 5, and 6 in Standard Grade Mathematics; (2) to describe the competencies shown in school work by pupils failing to achieve at least grade 6 in Standard Grade Mathematics; and (3) to identify any changes that might seem desirable in grade-related criteria which might lead to improvements in the teaching of basic competencies in mathematics. Examination scripts and classroom work of (n=1,188) students in grades 3 to 7 were collected and analyzed. This report discusses the findings in the following areas: number, measure, relationships, shape, information handling, interpreting a task, doing a task, and completing a task. Significant differences were found between grades 4 and 5 in examination performance. An appendix contains criteria descriptors used in analysis of Standard Grade Mathematics. (MKR)

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ED 373 955

Standard Grade Mathematics Achievements and Competences Grade 3 to 6

Marion Devine
Harry Black
Donald Gray

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Standard Grade Mathematics
Achievements and Competences
Grade 3 to 6

Marion Devine
Harry Black
Donald Gray

The Scottish Council for Research in Education

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Special thanks are due to those teachers who allowed us into their classrooms to gather information from both themselves and their pupils.The schools with which we worked most closely are listed below.

Thank you also to Kay Young our project secretary who coped admirably with a complex and difficult layout.

Marion Devine

Harry Black

Donald Gray

December 1993

Banff Academy	Grampian Region
Garnock Academy	Ayr Division
Gleniffer High School	Renfrew Division
Grangemouth High School	Central Region
Inveralmond Community School	Lothian Region
Stranraer Academy	Dumfries and Galloway Region

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1 Introduction

Aims of study

The first Standard Grade courses have now been in place for almost ten years. The curriculum is firmly established in schools and teachers are familiar with the criteria which are used both to plan and assess courses. The aims of this study provide the opportunity to reflect on some aspects of Standard Grade Mathematics.

The three aims of the study are as follows

- to describe the actual mathematical competences of pupils gaining grades 3, 4, 5 and 6 in Standard Grade Mathematics
- to describe the competences shown in school work by pupils failing to achieve at least grade 6 in Standard Grade Mathematics
- to identify any changes which might seem desirable in grade-related criteria which might lead to improvements in the teaching of basic competences in mathematics

Method

In order to meet the aims of the study, information was collected from two different sources, examination scripts and classroom work. In each case the performance of pupils was analysed according to an agreed framework of competences. Since we were mainly interested in pupils of average and below average attainment, our sample was drawn from large schools across Scotland which were likely to provide substantial numbers of pupils at each grade level. Examination scripts from two consecutive years were analysed and a number of schools were visited in order to study the work of a selected number of low attaining pupils.

Selecting the sample

The majority of the Standard Grade examination scripts was drawn from a core group of ten secondary schools. These were large schools which were likely to give us reasonable numbers of candidates at each grade level. For each school the scripts of ten candidates at each of grades 3, 4, 5 and 6 were collected. Since pupils who are awarded grade 7 are likely to show limited evidence of attainment, a larger sample of grade 7 papers was selected. These papers were gathered from a total of 30 schools including the ten core schools. The same schools were used for both the 1991 and 1992 analyses. The total number of scripts available was 651 in 1991 and 537 in 1992. Table 1.1 shows the number of scripts at each grade.

Table 1.1 Number of scripts analysed for each year

Overall grade	1991	1992
Grade 3	100	100
Grade 4	100	100
Grade 5	100	101
Grade 6	100	99
Grade 7	251	137

The framework of competences

At an early stage in the project a working party was set up to discuss the details of a framework of competences which could be used to analyse both classroom work and pupils' responses to the Standard Grade examination. The group had the option of choosing among existing options such as those used for the Assessment of Achievement Programme in Scotland or the Assessment of Performance Unit in England and Wales; to modify more recent criteria such as those of the 5-14 Development Programme or the National Curriculum in England and Wales; or to generate its own criteria which might, for example, have been based on mathematical 'life-skills'. After debate it was felt that since both the Scottish Examination Board (SEB) and teachers work to the Extended Grade Related Criteria (EGRC) of Standard Grade when setting questions or planning a course, it was preferable to retain the EGRC as a basis for the framework, to expand some sections and to add a small number of criteria which appeared not to be included. The additions are

- a fuller list of problem-solving strategies (from 5-14 guidelines)
- rough equivalences of metric/imperial units (a useful 'life-skill')
- approximation of calculations (essential when using a calculator)

The full profile of competences is given in Appendix A.

The examination papers

Most candidates who sit the Standard Grade Mathematics examination are advised to attempt papers set at two consecutive levels, either Credit and General or General and Foundation. Each level consists of two papers; Paper 1 focuses on the assessable element Knowledge and Understanding (KU), Paper 2 on the element Reasoning and Applications (RA). Low attaining candidates may be advised to attempt only the Foundation Level papers. Since we were interested in average and below average attainers, the bulk of the papers were at the lower levels. A small number of candidates attempted only one part of a paper and these scripts were excluded from the analyses . Tables 1.2a and 1.2b indicate the relationship between the final awards of our sample of candidates and the level of papers attempted in each year.

Table 1.2a: Final award by level of paper (1991)

	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total
Credit/General	63	12	-	-	-	7
General/Foundation	36	87	63	40	53	279
Foundation only			33	52	174	260

Table 1.2b: Final award by level of paper (1992)

	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total
Credit/General	44	6	3	-	-	53
General/Foundation	51	90	74	28	37	280
Foundation only	-	-	22	59	90	171

Analysing the examination papers

The Extended Grade Related Criteria (EGRC) are used by the setters in preparing and selecting questions for the various examination papers. However, marking is not based on direct grading of the candidates' responses, i.e. the response is not directly matched to a statement of the EGRC. Within each level of paper (Credit, General or Foundation), a mark is given for each question, or part of a question. A total mark is calculated for each assessable element and cut-off scores are used to define the upper and lower grades for each level. For example, at Foundation Level, pupils above the upper cut-off score will be awarded a grade 5 and pupils below the upper cut-off score but above the lower cut-off score will be awarded a grade 6. Because we were interested in the actual competences of pupils at different levels, our analysis had to be more direct.

The profile of competences which had been prepared for use in analysing classroom practice and which has been described previously was also used to analyse the examination papers. Two researchers, working independently, classified each question or part of a question in the papers according to the competences on the profile. Differences, where they occurred, were discussed and agreement reached to ensure uniformity of analysis. The full profile is included as Appendix 1. A total of 38 aspects of Knowledge and Understanding and 24 aspects of Reasoning and Applications were used in the analysis. However, for the purposes of presenting the results these aspects were regrouped to provide manageable sets of criteria. The elements Knowledge and Understanding and Reasoning and Applications were regrouped under headings derived from the attainment outcomes and the programmes of study from *Mathematics 5-14*. The results for KU are reported under the following five headings: Number, Measure, Relationships, Shape and Information Handling. The results for RA are listed under headings derived from the outcome Problem Solving and Enquiry, i.e. Interpreting

the task, Doing the task and Completing the task. Some of the competences describe progression across all three levels while others apply to only one or two levels. Since not all competences were covered by the examinations, the profile of competences in Appendix 1 indicates those which were included in the 1991 and/or 1992 papers. The link with 5-14 categories is also shown.

Opportunities for success

Different opportunities were provided by the different papers. Table 1.3 shows the total number of criteria in which pupils had the opportunity to show competence in the different combinations of papers set.

Table 1.3 Number of individual criteria represented in 1991 and 1992 examination papers

	Number of criteria					
	Credit		General		Foundation	
Combination of papers	1991	1992	1991	1992	1991	1992
Credit/General	32	23	33	31	14	13
General/Foundation			33	31	31	30
Foundation only			2	1	28	29

The number of opportunities offered had to be taken into consideration when calculating the number of successful candidates for any single criterion. In each case where percentages have been used, these are based on the number of candidates who had the opportunity to demonstrate success.

Study of classroom work

Each of a selected group of six schools was visited by one or two researchers over a period of one week. During this time the work of a sample of pupils was analysed according to the framework of competence and information was collected from the teachers on their estimates of the performance of pupils on the same framework. Further information about this part of the study can be found in Chapter Four.

Structure of report

For each of the pupils in the school samples, assessments are available from a number of sources - researchers, teachers and examination performance. Chapter Two discusses the extent to which there is agreement amongst these.

Chapter Three focuses on the results from the 1991 and 1992 examination scripts. Each section within the chapter relates to one of the outcomes derived from the document *Mathematics 5-14* and the attainments of pupils at the different grades are highlighted and discussed. Particular attention is paid to those criteria which show evidence of significant

differences* in attainment between grades 4 and 5. A summary of key findings is provided showing what pupils can do in examinations at grades 3-6 together with a list of those competences which distinguish between grade 4 and grade 5 pupils

Chapter Four considers the attainment of low attaining pupils in the classrooms which were visited. Results from class work are discussed. A summary of the classroom competences of pupils estimated to be classified grade 7 completes the chapter.

The final chapter draws the report to a conclusion and highlights a number of points for discussion. Some of these have implications for the Examination Board and some have implications for teachers.

* Significant differences have been established using the Chi-squared test. The level of significance is set at < 0.01.

2 Comparisons

Sources of assessment

During the course of this study account was taken of the way in which three groups - researchers, teachers and the Examination Board - assessed the same set of pupils on the same criteria. Similarities and differences between the assessments of the three groups are discussed below.

Teachers' estimates and SEB grades

Teachers provided two estimated awards for each pupil in Knowledge and Understanding and Reasoning and Applications. The actual awards were obtained from the SEB after the 1992 examination. Table 2.1 shows how the two sets of awards compare. Of the 74 pupils selected, one person only did not sit the examination.

Table 2.1 *Estimated awards (1992)* *Actual awards (1992)*

Grade level	KU	RA	Grade level	KU	RA
3	-	-	3	1	-
4	1	1	4	6	4
5	30	17	5	33	18
6	29	35	6	19	23
7	14	21	7	14	28

Teachers' grades and examination grades for individual pupils are the same in about half of all cases. In Knowledge and Understanding there was agreement on 36 out of 73 cases and in Reasoning and Applications there was agreement in 37 out of 73 cases. Table 2.2 shows that the differences are not consistently in any one direction.

Table 2.2 Differences between teacher and SEB grades for each element

	KU	RA
Number of cases agreed	36	37
Teacher estimates a lower grade	25	16
Teacher estimates a higher grade	12	20

Particularly in Knowledge and Understanding there is a tendency for teachers to underestimate the grades of pupils. In most cases the difference was only one grade within Foundation Level, i.e. grade 7 instead of grade 6 or grade 6 instead of grade 5. For six candidates the

difference meant an underestimation across the level, i.e. from a Foundation Level grade to a General Level grade.

Teacher assessment and exam performance on individual criteria

A study was also made of the differences in teacher assessment and examination performance in relation to those individual criteria which were tested in the examination. Table 2.3 shows that in Knowledge and Understanding a total of 19 Foundation and 17 General Level criteria were available for comparison. In Reasoning and Applications there were 7 Foundation and 9 General Level criteria.

Table 2.3 Number of agreements and differences between teacher assessment and examination attainment at the level of individual criteria

	KU (F)	(G)	RA (F)	(G)
Agreement	8	10	3	5
Teacher assessment lower	-	4	-	3
Teacher assessment higher	11	3	4	1
Total	19	17	7	9

Teachers' assessments suggest that pupils do better in the classroom on a range of Foundation Level criteria in both Knowledge and Understanding and Reasoning and Applications than they do in the examination. At General Level the situation is less clear-cut. More than half of the assessments for Knowledge and Understanding in the classroom match performance in the examination. The remainder are almost evenly split between higher and lower assessments. Fewer criteria for Reasoning and Applications are available for comparison, but again the tendency is for teachers to assess their pupils higher at Foundation Level and lower at General Level.

Teacher and researcher results

Both teachers and researchers used the same profile of competences to record the attainments of the pupils. The teacher's profile was more extensive as researchers had a limited amount of time to study pupils' attainments. The analysis of differences shown in Table 2.4 deals with criteria where information is available from both teachers and researchers.

Table 2.4 Agreements and differences between teachers and researchers

	KU (F)	(G)	RA (F)	(G)
Agreement	19	9	9	7
Researcher assessment higher	-	16	-	3
Teacher assessesment higher		2	-	2 -
Total	21	25	11	10

At Foundation Level there were very few differences between teachers' and researchers' assessments. At General Level, in all cases where there was a difference, the researchers consistently rated pupils more highly than teachers. Later in the report we shall refer to the support given to pupils in the classroom and to the fact that their written work tended to be discussed and corrected on the spot. Researcher assessment of completed written work is, therefore, a measure of the pupil's attainment given full support and, as such, is likely to be more optimistic than teacher assessment. Differences may also be related to teacher expectations. Pupils' introduction to General Level criteria was limited. More support would tend to be given during class as they would not be expected to attain these criteria unaided. By contrast at Foundation Level, where there was virtually no difference between teacher and researcher assessments, most of the work in class is focused on introducing, developing and practising Foundation Level criteria. Teachers are likely to have higher expectations of pupils in these circumstances.

Conclusion

Candidates who were classified as grade 7 had few opportunities to demonstrate attainment on General Level criteria in the examination as they mostly attempted only the Foundation Level papers. Researchers consistently noted more success on General Level criteria in classwork than was reported by teachers. This was at least partly because of the need to base most of our evidence on written work completed with the full support of the teacher. It may also be due to some extent to teacher expectations for low attaining pupils.

This sample of teachers tended to underestimate pupils' performance in Knowledge and Understanding in the final examination. However, the same teachers, when asked to provide a detailed profile of what pupils could do in the classroom, indicated that they could do more than they were able to demonstrate in the examination. This suggests a fairly sophisticated use of teacher assessment. In one case they were asked to provide an estimate of the final award in each element as they do for the Examination Board. In the other case they were asked to think about each pupil in detail and to record a grade (3, 4, 5, 6 or 7) against each criterion on the profile to indicate what, in their professional judgement, each pupil could do. At least at Foundation Level, teachers' assessments of their pupils' ability in the classroom tended to be corroborated by the assessment of the researchers. The finding that teachers assess the ability of their pupils more highly on individual criteria than is evidenced by their performance in the examination cannot be a surprise. Pupils will behave in a different way in a supportive and non-threatening learning environment from that in a high-stakes testing situation.

The next chapter provides details of how pupils behave in the examination situation. Each section of the chapter relates to performance on one group of criteria and the same structure is maintained throughout.

3 Analysis of examination performance

Categories of mathematics

One of the aims of the project was to describe the actual mathematical competences of pupils gaining grades 3, 4, 5 and 6 in Standard Grade Mathematics. Examination scripts from the years 1991 and 1992 were analysed in order to fulfil this aim. The five categories of Knowledge and Understanding and the three categories of Reasoning and Applications listed below are used in this chapter to describe the analysis.

Knowledge and Understanding	Reasoning and Applications
Number	Interpreting a task,
Measure	Doing a task
Relationships	Completing a task
Shape	
Information Handling	

The competences of pupils who gained grades 3, 4, 5 and 6 are described for each category separately. Of special interest is the set of competences which are held by pupils classified as attaining particular grades. These 'grade competences' are the best description we can offer of what a pupil gaining , say, grade 5 can actually do.

We have defined 80% as a base-line for 'grade competences', i.e., where 80% or more of any one group of candidates awarded a particular grade successfully attain a criterion, then that is a competence for that grade.

Although our main interest in pupils classified as grade 7 was in how they performed in the classroom, information about their performance in the examinations was also gathered. This allowed the possibility of comparing the competences they displayed in the classroom with those they exhibited in the external examination.

Presentation of the findings

The findings related to pupil performance in the sub-categories of Knowlege and Understanding and Reasoning and Applications are presented separately for Credit , General and Foundation Level criteria. The grade competences for each group of criteria are summarised at the end of each section and a full list is gathered together at the end of the chapter.

Special attention has been paid to the boundary between General Level and Foundation Level i.e. between grade 4 and grade 5. This is an area of concern for both mathematics teachers and the Examination

Board. In mathematics, the distribution of grades peaks at grade 5 and any information from this study which might help teachers to move pupils on to grade 4 would seem to be helpful. We have, therefore, concentrated our search for significant differences on this boundary. A summary list of all those criteria which show significant differences between grades 4 and 5 is provided at the end of the chapter.

The results for each set of competences have been presented in a uniform layout and sequence. The sequence is as follows

- level of criteria being reported (Credit, General or Foundation).
- description of competences which are included in both 1991 and 1992 examinations.
- description of competences which were included in only one year's examination
- profiles showing the percentage of successful pupils in those competences which were included in both 1991 and 1992 examinations. The profiles for Credit Level show grades 3 and 4 only. The profiles for General Level cover the whole range from grades 3 to 7 and the Foundation Level profiles cover the range from grade 4 to grade 7
- a table showing the percentage of pupils successful in competences which appeared in only one year
- comments on patterns of performance over the two years
- a list of grade competences, i.e. those competences which are attained by 80% or over of candidates at each grade. Some competences were attained in both years, some in only one year
- where appropriate, a list of attainments which show a significant difference between grades 4 and 5 indicating whether they were significant in one year only or in both years.

Further important notes on the profiles

- in each case the pupils are sorted by the overall grade which they were awarded by the SEB for mathematics.
- in all cases the percentage is of those pupils who had the opportunity to demonstrate competence.
- profiles rather than bar graphs are used in order to make the patterns and relationships easier to visualise.

Knowledge and Understanding (Number)

Credit Level criteria (Number)

Four criteria relating to Number at Credit Level were available in both the 1991 and the 1992 examinations. These were:

K22 Select steps for routines, e.g. joint variation, depreciation

K28 Cumulative compound interest

K30 Round to significant figures

K39 Use the laws of indices in standard notation

In 1991 two further criteria were available:

K23 Select steps for inverse proportion

K27 Arithmetic operations on surds, fractions, real numbers

Figure 3.1 shows the results for those criteria available in both 1991 and 1992. Table 3.1 shows the percentage of candidates successful in those criteria which were only available in one year.

Figure 3.1 Percentage of pupils successful at Credit Level competences in Number

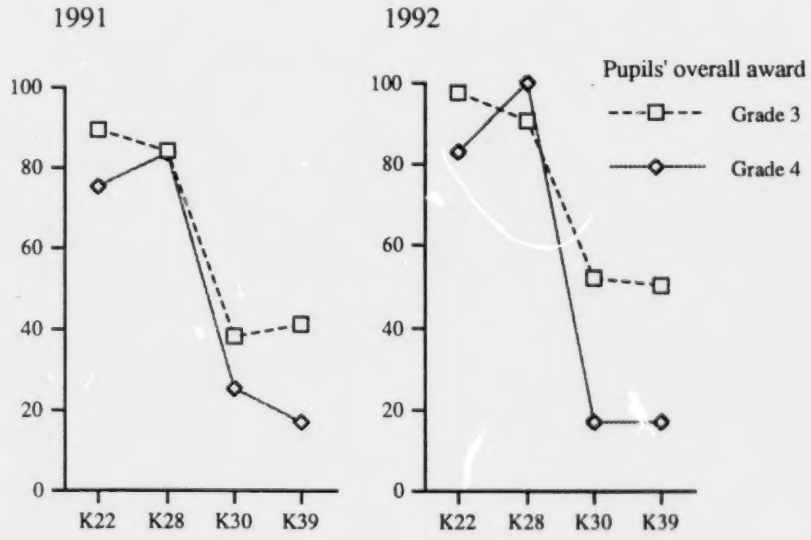


Table 3.1 Percentage of pupils successful in criteria available in one year only

	Grades	
1991	3	4
K23	30	8
K27	41	8

Patterns over two years

The pattern of results in both years is almost identical for both grades in all four criteria. Apart from K28, where more than 90% of both groups are successful, more grade 3 than grade 4 pupils demonstrate success.

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4
K22	Select steps for routines, e.g. joint variation	Yes	Yes
K23	Select steps for inverse proportion	-	-
K27	Arithmetic operations on surds, fractions, real numbers	-	-
K28	Cumulative compound interest	Yes	Yes
K30	Round to significant figures	-	-
K39	Use the laws of indices in standard notation	-	-

General Level criteria (Number)

The following criteria were available at General Level in the category Number in both 1991 and 1992.

K7	Read instruments using interpolation of scales
K27	Add and subtract integers mainly in practical context
K38	Convert units, e.g. capacity, area
K39	Use standard notation

Other criteria available in one year only:

K8	Read negative numbers on scales (1991)
K28	Express one quantity as a percentage of another (1991)
K30	Round to required number of decimal places (1991)
K23	Select steps for inverse proportion (1992)
K29	Money calculations, e.g. simple interest on fraction of year, exchange rates, premiums (1992)

Figure 3.2 shows the results for those criteria available in both 1991 and 1992. Table 3.2 shows the percentage of candidates successful in those criteria which were only available in one year.

Figure 3.2 Percentage of pupils successful at General Level competences in Number

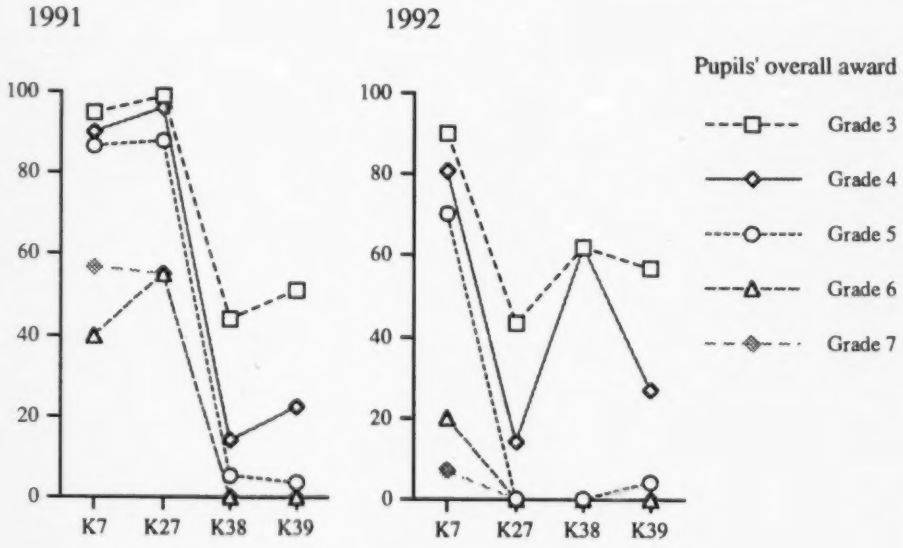


Table 3.2 Percentage of pupils successful in criteria available in one year only

	Grades				
1991	3	4	5	6	7
K8	98	99	100	80	0
K28	84	45	16	5	0
K30	72	43	10	2	0

	Grades				
1992	3	4	5	6	7
K23	53	31	18	4	0
K29	78	69	26	4	0

Patterns over two years

In both years, the peaks and troughs of attainment are similar for all levels i.e. the relative difficulty of the various criteria is more or less constant. The trend for both years also reflects the grade levels with the number of pupils being successful decreasing from Grade 3 to Grade 7. However, there is a considerable swing between 1991 and 1992 on the number of pupils being successful at K 27 and in the relative difficulty of the criterion compared with others in the group. The difference illustrates the problems in setting questions intended to assess a particular criterion. Factors other than the ability to add and subtract integers can influence the difficulty of a question. These might include the context of the question, the language used to phrase the question or the possibility that a correct response is dependent on successfully completing a previous section of the question. This problem recurs throughout the detailed report on individual criteria and will be explored further later.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
K7	Read instruments (using interpolation of scales)	Yes	Yes	Yes	-	-
K8	Read negative numbers on scales	Yes	Yes	Yes	Yes	-
K23	Select steps for inverse proportion	-	-	-	-	-
K27	Add and subtract integers	Yes	Yes	Yes	-	-
K28	Express one quantity as a percentage of another	Yes	-	-	-	-
K29	Money calculations	-	-	-	-	-
K30	Round to required number of decimal places	-	-	-	-	-
K38	Convert units, e.g. capacity, area	-	-	-	-	-
K39	Use standard notation	-	-	-	-	-

Significant differences between grades 4 and 5

Those criteria for which the proportion of pupils attaining grades 4 and 5 was significantly different are listed below.

K28 (1991) Express one quantity as a percentage of another

K29 (1992) Money calculations (exchange rates, premiums, interest on fractions of year)

K30 (1991) Round to required number of decimal places

K38 (1992) Convert units, e.g. capacity, area

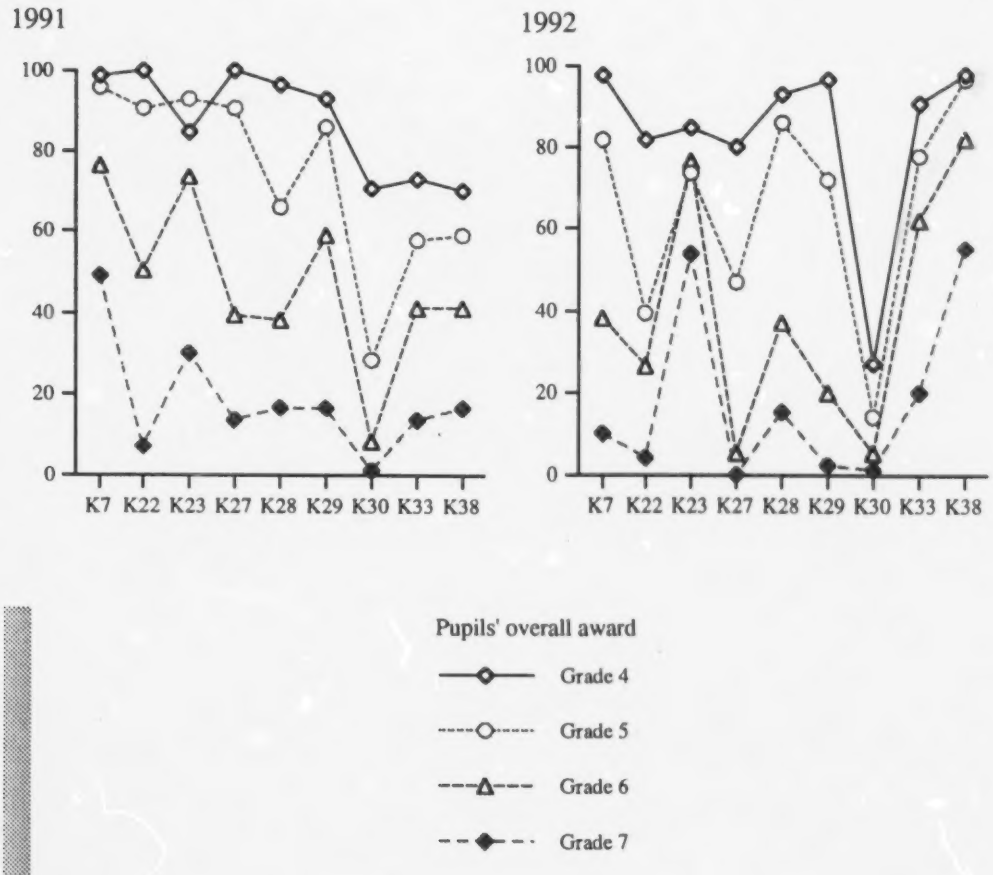
Foundation Level criteria (Number)

Nine criteria within the category Number were available in both the 1991 and 1992 papers.

K7	Read instruments with straightforward scales
K22	Select correct arithmetic operation
K23	Select steps for direct proportion
K27	Four rules with whole numbers and decimals
K28	Calculate simple percent of a quantity
K29	Money calculations (income, savings, bills, HP, VAT, wages)
K30	Round to nearest unit
K33	Calculate duration of time
K38	Convert within units (metric length, weight)

Figure 3.3 shows the results for the criteria available in both 1991 and 1992. No other criteria were available in separate years.

Figure 3.3 Percentage of pupils successful at Foundation Level competences in Number



Patterns over the two years

The patterns of success are relatively stable over both years. The number of pupils demonstrating success falls in line with the grade levels. Each group of candidates demonstrates a similar pattern of the level of relative difficulty. The peaks and the troughs of success are similar for all groups. Over 80% of grade 4 candidates demonstrate success on six of the nine criteria.

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
K7	Read instruments (straightforward scales)	Yes	Yes	-	-
K22	Select correct arithmetic operation	Yes	Yes	-	-
K23	Select steps for direct proportion	Yes	Yes	-	-
K27	Four rules(whole numbers, decimals)	Yes	Yes	-	-
K28	Calculate simple percent of a quantity	Yes	Yes	-	-
K29	Money calculations (income, savings, bills, HP, VAT, wages)	Yes	Yes	-	-
K30	Round to nearest unit	-	-	-	-
K33	Calculate duration of time	Yes	Yes	-	-
K38	Convert within units (metric length, weight)	Yes	Yes	Yes	-

Significant differences between grades 4 and 5

Those criteria which show a significant difference between Grades 4 and 5 are listed below.

K22 (1992) Select correct arithmetic operation

K27 (1992) Four rules with whole numbers and decimals

K28 (1991) Calculate simple percent of a quantity

K30 (1991) Round to nearest unit

Knowledge and Understanding (Measure)

Credit Level criteria (Measure)

Only one criterion relating to Measure at Credit Level was available in both the 1991 and the 1992 examinations. This was:

K21 Volume of a composite solid

Two other criteria were available in separate years:

K19 (1991)	Calculate the area of a circle
K18 (1992)	Calculate the length of an arc of a circle

The results are given in Tables 3.3 and 3.4 below.

Table 3.3 *Percentage of pupils successful at Credit Level competences in Measure*

	Grades	
K 21	3	4
1991	33	17
1992	34	0

Table 3.4 *Percentage of pupils successful in criteria available in one year only*

	Grades	
1991	3	4
K19	57	8

	Grades	
1992	3	4
K18	64	17

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

No criteria were attained by over 80% of pupils. As indicated in the introduction to the report, the number of pupils awarded a grade 4 who had the opportunity to attempt Credit Level criteria was very low. It is, therefore, difficult to draw any worthwhile conclusions about their competences.

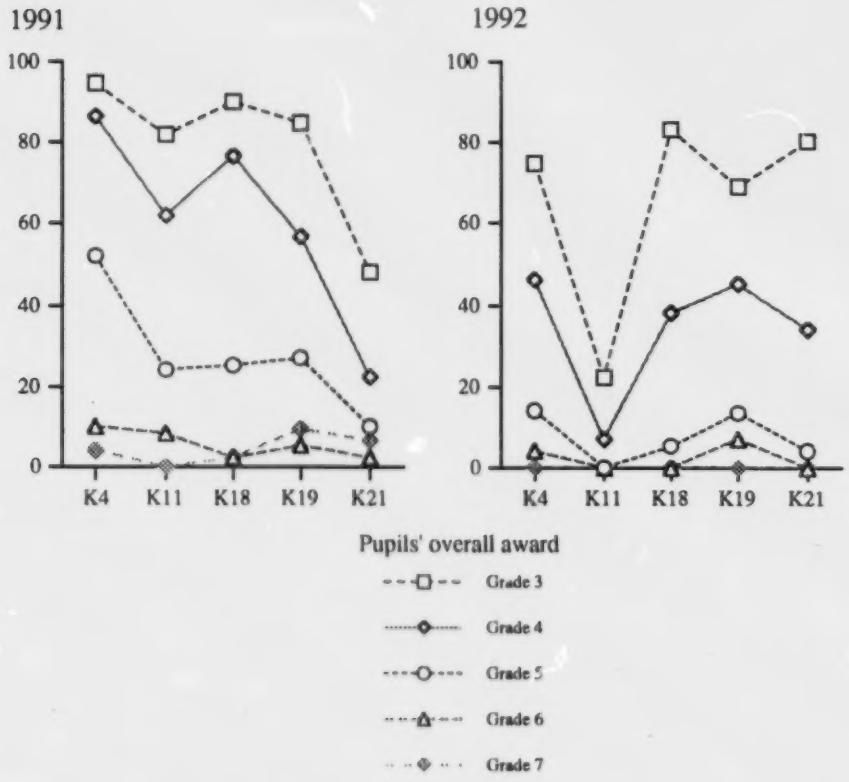
General Level criteria (Measure)

The following criteria were available at General Level in the category Measure in both 1991 and 1992.

K4	Interpret scale drawings (scales as ratio or scaled line)
K11	Construct scale drawings with scale not given
K18	Calculate the circumference of a circle
K19	Calculate the area of triangle, kite, parallelogram, rhombus, composite figure, circle
K21	Calculate volume of cylinder, triangular prism

Figure 3.4 shows the results for the criteria available in both 1991 and 1992. No other criteria in this category were available in separate years.

Figure 3.4 Percentage of pupils successful at General Level competences in Measure



Patterns over two years

Similar patterns of results are shown in both 1991 and 1992. The number of pupils demonstrating success falls in line with the grade levels. Each group of candidates demonstrates a similar pattern of the level of relative difficulty. The peaks and the troughs of success are similar for all groups. Compared with 1991, the criterion K11 proved more difficult in 1992, particularly for grade 3 and grade 4 candidates.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
K4	Interpret scale drawings (scales as ratio)	Yes	Yes	-	-	-
K11	Construct scale drawings (scale not given)	Yes	-	-	-	-
K18	Calculate circumference of a circle	Yes	-	-	-	-
K19	Calculate area of geometric figures	Yes	-	-	-	-
K21	Calculate volume	Yes	-	-	-	-

Significant differences between grade 4 and grade 5
This is a group of criteria which appears to discriminate well between the two grade levels. K4 and K18 show a significant difference in both 1991 and 1992. The full list is given below.

K4 (1991, 1992)	Interpret scale drawings with scales as ratio, representative fraction or scaled line
K11 (1991)	Construct scale drawings with scale not given
K18 (1991, 1992)	Calculate the circumference of a circle
K19 (1992)	Calculate the area of triangle, kite, parallelogram

Foundation Level criteria (Measure)

Two criteria within the category Measure were available in both the 1991 and 1992 papers.

K4 Interpret scale drawings with scales expressed in words

K21 Calculate the volume of a cube or cuboid

Other criteria were available in one year only:

K19 Calculate the area of a rectangle, square and right angled triangle (1991)

K18 Calculate the perimeter of a rectilinear figure (1992)

Figure 3.5 shows the results for the criteria available in both 1991 and 1992. Table 3.5 shows the percentage of successful pupils for the criteria which were available in one year only.

Figure 3.5 Percentage of pupils successful at Foundation Level competences in Measure

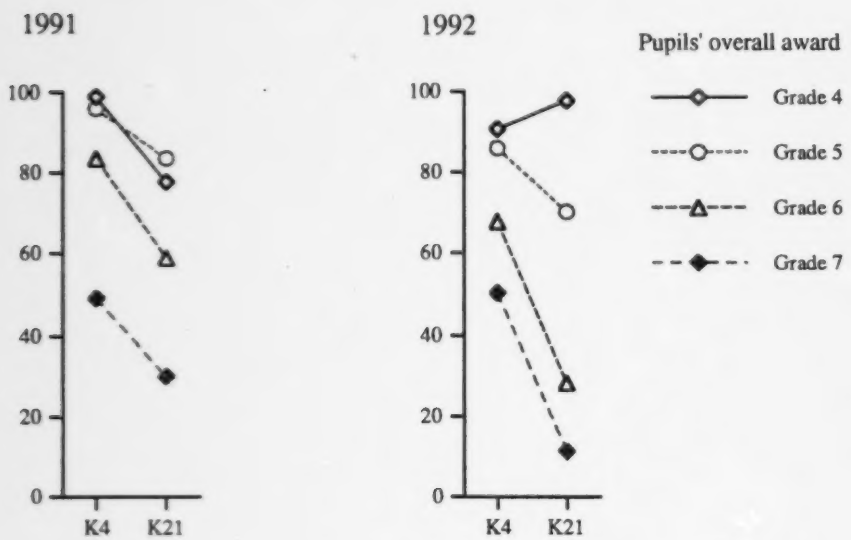


Table 3.5 Percentage of pupils successful in criteria available in one year only

	Grades			
1991	4	5	6	7
K19	96	74	51	21

	Grades			
1992	4	5	6	7
K18	88	79	80	55

Patterns over the two years

Over the two years K4 is generally attained by more pupils at each level than K21. The number of pupils demonstrating success decreases in line with the decrease in grade levels.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
K4	Interpret scale drawings (scales expressed in words)	Yes	Yes	Yes	-
K18	Calculate the perimeter of a rectilinear figure	Yes	-	-	-
K19	Calculate the area of a rectangle, square, right angled triangle	Yes	Yes	Yes	-
K21	Calculate the volume of a cube/cuboid	Yes	Yes	-	-

Significant differences between grades 4 and 5
The only significant difference between grades 4 and 5 is the 1991 criterion K19 - the ability to calculate the area of a rectangle, square or right angled triangle.

Knowledge and Understanding (Relationships)

Credit Level criteria (Relationships)

Six criteria relating to Relationships at Credit Level were available in both the 1991 and the 1992 examinations. These were:

K6	Know the graph of mx+c has gradient *m* and intercept *c*
K24	Solve quadratic equations
K25	Solve simultaneous equations
K26	Solve inequations
K31	Evaluate formulae with indices
K34	Manipulate expressions of the form f(x)/g(x)
K39	Use the laws of indices in standard notation

In 1992 one further criterion was available:

K5 Identify the effect of a change of variable

Figure 3.6 shows the results for those criteria available in both 1991 and 1992. Table 3.6 shows the percentages of candidates successful in the criterion available only in 1992.

Figure 3.6 Percentage of pupils successful at Credit Level competences in Relationships

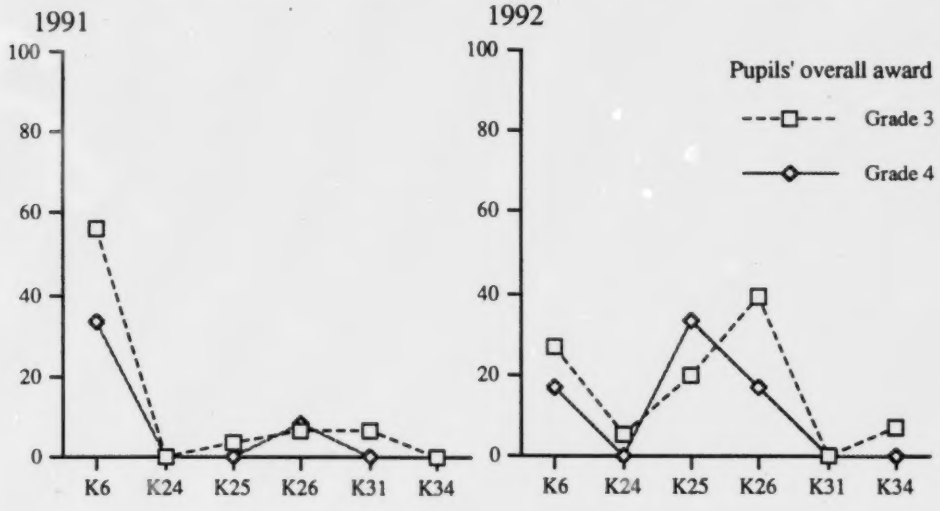


Table 3.6 Percentage of pupils successful in criteria available in one year only

	Grades	
1991	3	4
K5	25	33

Patterns over two years

Very few pupils in the sample performed successfully on this set of criteria. K24, K31 and K34 were attained by less than 10% of either grade 3 or grade 4 candidates in both years. Only K6 in 1991 - Know the graph of y=mx + c - was attained by over half of grade 3 pupils.

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

There were no grade competences in this group of criteria.

General Level criteria (Relationships)

The following criteria were available at General Level in the category Relationships in both 1991 and 1992.

K14	Construct formulae in symbols to describe a given relationship
K24	Solve simple equations with non-negative solutions
K31	Evaluate formulae in symbols
K34	Collect terms, remove brackets, find common factor

In 1992 one further criterion was available:

K5	Identify change of features in a graph

Figure 3.7 shows the results for the criteria available in both 1991 and 1992. Table 3.7 shows the percentage of pupils successful in the criterion which was available only in 1992.

Figure 3.7 Percentage of pupils successful at General Level competences in Relationships

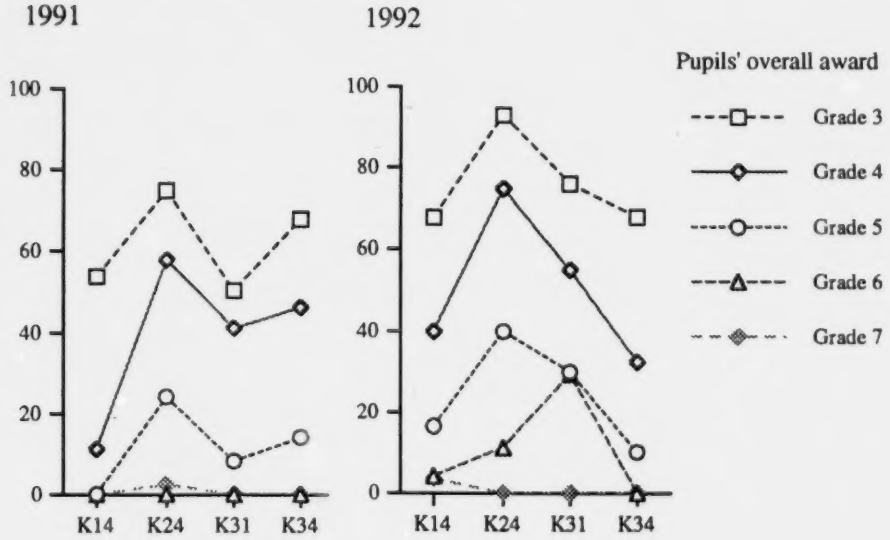


Table 3.7 Percentage of pupils successful in criteria available in one year only

	Grades				
1991	3	4	5	6	7
K5	97	94	77	39	22

Patterns over two years

Similar patterns of results are shown in both 1991 and 1992. The number of pupils demonstrating success decreases as the grade level decreases. Each group of candidates demonstrates a similar pattern of the level of relative difficulty. In both years K24 - the ability to solve simple equations is attained by more pupils at the higher levels than the other criteria.

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
K5	Identify change of features in a graph	Yes	Yes	-	-	-
K14	Construct formulae in symbols	-	-	-	-	-
K24	Solve simple equations	Yes	-	-	-	-
K31	Evaluate formulae in symbols	-	-	-	-	-
K34	Simple manipulation	-	-	-	-	-

Significant differences between grades 4 and 5

This set of criteria shows a number of consistent significant differences between grades 4 and 5. The full list is shown below

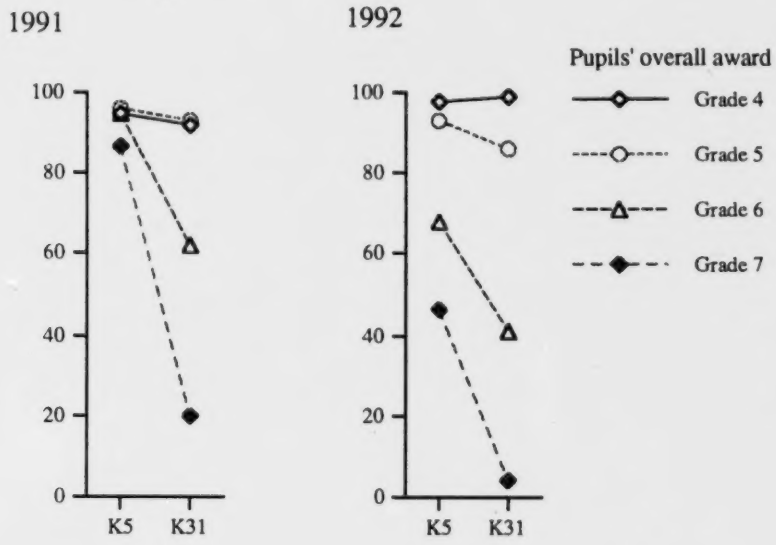
K14 (1992)	Construct formulae in symbols
K24 (1991, 1992)	Solve simple equations
K31 (1991, 1992)	Evaluate formulae given in symbols
K34 (1991)	Collect terms, remove brackets, find common factor

Foundation Level criteria (Relationships)
The following criteria were available at Foundation Level in the category Relationships in both 1991 and 1992.

K5	Identify trend in a line graph where there is one trend
K31	Evaluate formulae expressed in words

Figure 3.8 shows the results for the criteria available in both 1991 and 1992. No other criteria in this category were available in separate years.

Figure 3.8 Percentage of pupils successful at Foundation Level competences in Relationships



Patterns over two years
Similar patterns of results are shown in both 1991 and 1992. Over 80% of candidates at all levels in 1991 were successful at K5 - identifying a trend in a graph. Neither of these criteria discriminate between grade 4 and grade 5 candidates.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
K5	Identify trend in a line graph	Yes	Yes	Yes	Yes
K31	Evaluate formulae expressed in words	Yes	Yes	-	-

Significant differences between grades 4 and 5
There were no significant differences between grades 4 and 5 on any of the criteria in this group.

Knowledge and Understanding (Shape)

Credit Level criteria

Only one criterion relating to Shape at Credit Level was available in both the 1991 and the 1992 examinations. This was:

K15 Solve scalene triangles using trigonometric ratio

One other criterion was available in 1991:

K17 Know the relationship between tangent and circle

The results are given in Tables 3.8 and 3.9

Table 3.8 Percentage of pupils successful at Credit Level competences in Shape

	Grades	
K 15	3	4
1991	24	48
1992	17	33

Table 3.9 Percentage of pupils successful in criteria available in one year only

	Grades	
1991	3	4
K17	16	8

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

No criteria were attained by over 80% of pupils. As indicated in the introduction to the report, the number of grade 4 pupils having the opportunity to attempt Credit Level criteria was very low. It is, therefore, difficult to draw any worthwhile conclusions about the fact that a higher percentage of grade 4 than grade 3 pupils were successful on K15.

General Level criteria (Shape)

The following criteria were available at General Level in the category Shape in both 1991 and 1992.

K15 Solve right angle triangles using trigonometric ratios

K16 Use Theorem of Pythagoras

K17 Know the properties of angles in a circle

In 1991 one further criterion was available:

K9 Recognise complex shapes, pyramid, cylinder, triangular prism

Figure 3.9 shows the results for the criteria available in both 1991 and 1992. Table 3.10 shows the percentage of pupils successful in the criterion available in 1991.

Figure 3.9 Percentage of pupils successful at General Level competences in Shape

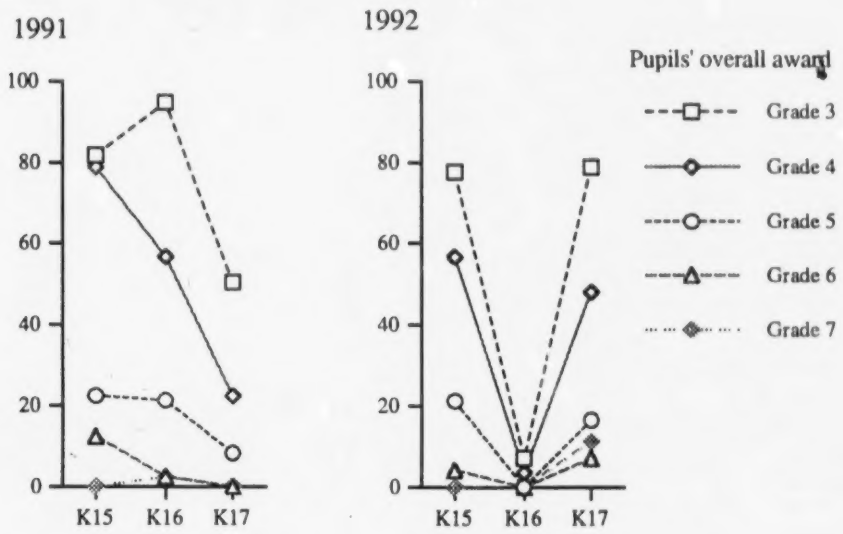


Table 3.10 Percentage of pupils successful in criteria available in one year only

	Grades				
1991	3	4	5	6	7
K9	67	53	24	10	8

Patterns over two years

The relative position of the various levels remains fairly constant within each year for two of the criteria. However, for K16 - using the Theorem of Pythagoras - the situation alters radically between the two years. In 1991, K16 is attained by more than 80% of grade 3 candidates while in 1992 less than 10% of grade 3 candidates are successful. Similar if less extreme results are evident for grades 4 and 5. The reasons for the apparent change in difficulty are explored later.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
K9	Recognise complex shapes	-	-	-	-	-
K15	Solve right angle triangles	Yes	Yes	-	-	-
K16	Use Theorem of Pythagoras	Yes	-	-	-	-
K17	Know the properties of angles in a circle	Yes	-	-	-	-

Significant differences between grades 4 and 5
K15 - the ability to solve right angle triangles - shows a significant difference between grades 4 and 5 in both 1991 and 1992. The full list is given below.

K9 Recognise complex shapes (1991)

K15 Solve right angle triangles (1992 and 1992)

K16 Use Theorem of Pythagoras (1991)

K17 Know the properties of angles in a circle (1992)

Foundation Level criteria (Shape)

Two criteria within the category Shape were available in both the 1991 and 1992 papers.

K9 Recognise 3D shapes - cube cuboid

K15 Calculate the third angle of a triangle

Other criteria were available in one year only:

K17 Know supplementary, complementary angles (1991)

K13 Plot/determine co-ordinates in first quadrant (1992)

Figure 3.10 shows the results for those criteria available in both 1991 and 1992. Table 3.11 shows the percentages of candidates successful in those criteria which were only available in one year.

Figure 3.10 Percentage of pupils successful at Foundation Level competences in Shape

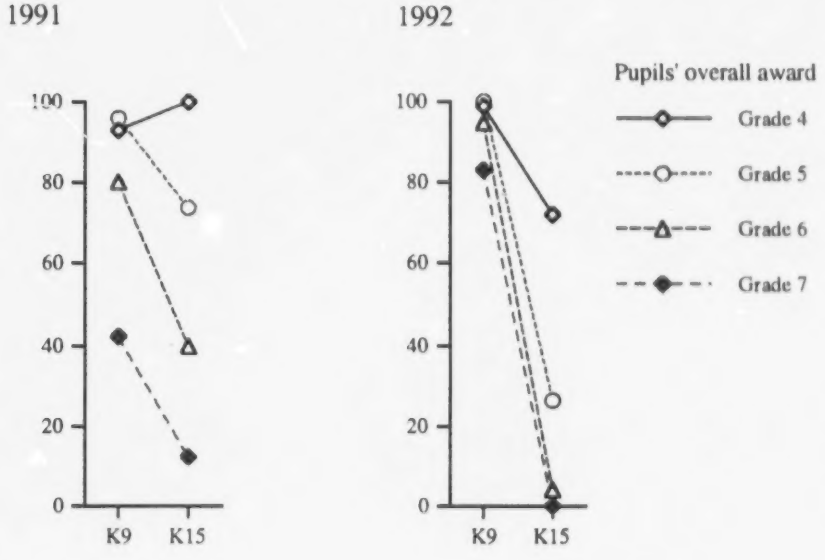


Table 3.11 Percentage of pupils successful in criteria available in one year only

	Grades					Grades			
1991	4	5	6	7	1992	4	5	6	7
K17	25	9	0	0	K13	99	98	98	86

Patterns over the two years

Apart from grade 4 candidates who perform well in both K9 and K15 in 1991, K9 is generally attained by more pupils than K15. More than 80% of all candidates are successful in 1992 at K9.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
K9	Recognise 3D shapes - cube cuboid	Yes	Yes	Yes	Yes
K13	Plot/determine co-ordinates in first quadrant	Yes	Yes	Yes	Yes
K15	Calculate the third angle of a triangle	Yes	-	-	-
K17	Know supplementary and complementary angles	-	-	-	-

Significant differences between grades 4 and 5
K15 - the ability to solve right angle triangles - is the only criterion which shows a significant difference between grades 4 and 5. It is significant in both 1991 and 1992.

Knowledge and Understanding (Information Handling)

Credit Level criteria

Two criteria relating to Information Handling at Credit Level were available in both the 1991 and the 1992 examinations. These were:

K1 Extract information from mathematical diagrams

K2 Interpret information from graphs with misleading scales

In 1992 one further criterion was available:

K10 Construct trigonometric graphs

Figure 3.11 shows the results for those criteria available in both 1991 and 1992. Table 3.12 shows the percentages of candidates successful in the additional criterion in 1992.

Figure 3.11 Percentage of pupils successful at Credit Level competences in Information Handling

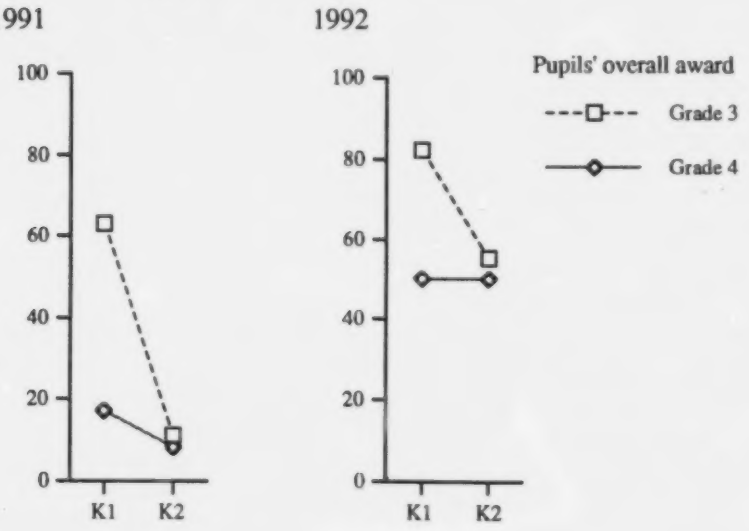


Table 3.12 Percentage of pupils successful in criteria available in one year only

	Grades	
1992	3	4
K10	70	67

Patterns over the two years

In both years, more grade 3 pupils were successful in extracting information from mathematical tables than in interpreting information from graphs with misleading scales. More grade 3 and grade 4 pupils were successful in both criteria in 1992 than in 1991.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

		Grade	3	4
K1	Extract information from tables		Yes	-
K2	Interpret information with misleading scales		-	-
K10	Construct trigonometric graphs		-	-

General Level criteria (Information Handling)

The following criterion was available at General Level in the category Information Handling in both 1991 and 1992 .

K10 Construct graphs when the scale is not given

Other criteria available in one year only:

K2 Interpret graphs using interpolation or combined graphs (1992)

K3 Interpret pie charts (using proportion of sectors (1991)

Table 3.13 shows the results for those criteria available in both 1991 and 1992. Table 3.14 shows the percentage of candidates successful in those criteria which were only available in one year.

Table 3.13 Percentage of pupils successful at General Level competences in Information Handling

	Grades				
K10	3	4	5	6	7
1991	96	79	64	56	43
1992	80	74	40	11	0

Table 3.14 Percentage of pupils successful in criteria available in one year only

	Grades				
1991	3	4	5	6	7
K3	51	29	16	0	4

	Grades				
1992	3	4	5	6	7
K2	93	84	82	57	27

Patterns over two years

Although K10 proved easier for more candidates at each level in 1991 than 1992, the relative position of grade level successes was maintained.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grades	3	4	5	6	7
K2	Interpret graphs using interpolation or combined graphs	Yes	Yes	Yes	-	-
K3	Interpret pie charts (using proportion of sectors)	-	-	-	-	-
K10	Construct graphs when the scale is not given	Yes	-	-	-	-

Significant differences between grades 4 and 5
The boundary between Foundation Level and General Level is of particular interest as a hurdle which appears to be difficult to surmount. In 1992 there was a significant difference in performance between grades 4 and 5 for K10, the ability to construct a graph where the scale and structure is not given.

Foundation Level criteria (Information Handling)

Two criteria within the category Information Handling were available in both the 1991 and 1992 papers.

K1 Interpret simple tables with up to 3 categories of data

K32 Calculate averages

Other criteria were available in one year only:

K2 Interpret graphs with straightforward scales (1992)

K3 Interpret piecharts (largest/smallest sector) (1992)

K10 Construct graphs given the scale and the structure (1991)

Figure 3.12 shows the results for those criteria available in both 1991 and 1992. Table 3.15 shows the percentages of candidates successful in those criteria which were only available in one year.

Figure 3.12 Percentage of pupils successful at Foundation Level competences in Information Handling

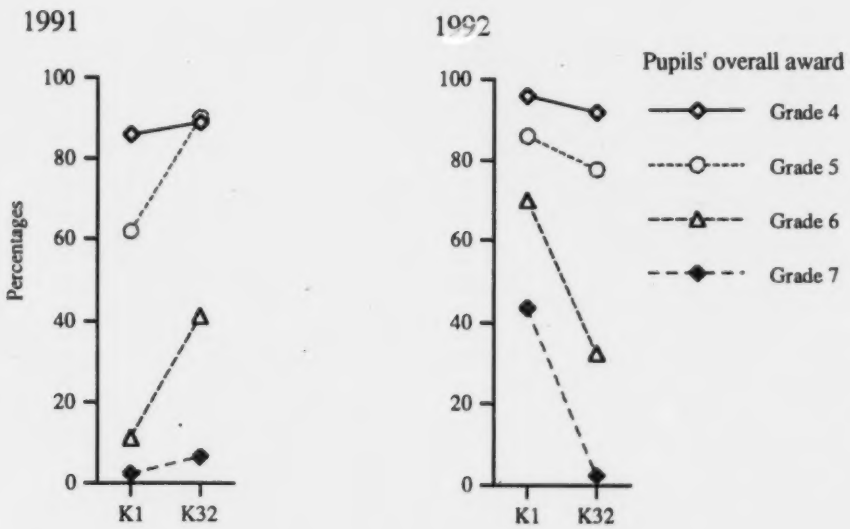


Table 3.15 Percentage of pupils successful in criteria available in one year only

	Grades			
1991	4	5	6	7
K10	91	76	58	43

	Grades			
1992	4	5	6	7
K2	99	98	95	87
K3	89	92	59	31

Patterns over the two years

Apart from K32 where an equal number of grade 4 and grade 5 candidates are successful, the level of success reflects the grade level, i.e. the number of candidates being successful decreases steadily from grade 4 to grade 7. For lower attaining candidates, K1 proved difficult for more candidates in 1991 than in 1992. Thus the relative difficulty of the two criteria was reversed in these two years.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
K1	Interpret simple tables (3 categories of data)	Yes	Yes	-	-
K2	Interpret graphs (straightforward scales)	Yes	Yes	Yes	Yes
K3	Interpret piecharts (largest/smallest sector)	Yes	Yes	-	-
K10	Construct graphs	Yes	Yes	-	-
K32	Calculate averages	Yes	Yes	-	-

At grades 4 and 5 candidates show competence in all Foundation Level criteria within the category Information Handling in at least one year. Grades 6 and 7 demonstrate competence in one criterion only - the ability to interpret graphs with straightforward scales.

Significant differences between grades 4 and 5

In 1991, K1 - the ability to interpret simple tables with up to 3 categories of data - was the only criterion in this category which showed a significant difference between grades 4 and 5.

Reasoning and Applications (Interpreting a task)

Credit Level criteria

Five criteria relating to Reasoning and Applications (Interpreting a task) at Credit Level were available in both the 1991 and the 1992 examinations. These were:

- R1 Interpret contexts involving excess information
- R4 Solve equations
- R6 Express a relatonship in symbols
- R24 Make deductions, introduce symbols to help solve problems
- R25 Decide the steps in a non-routine problem

One further criterion was available in 1991 only:

- R9 Combine information, draw inferences

Figure 3.13 shows the results for those criteria available in both 1991 and 1992. Table 3.16 shows the percentages of candidates successful in the additional criterion in 1991.

Figure 3.13 Percentage of pupils successful at Credit Level competences in Interpreting a task

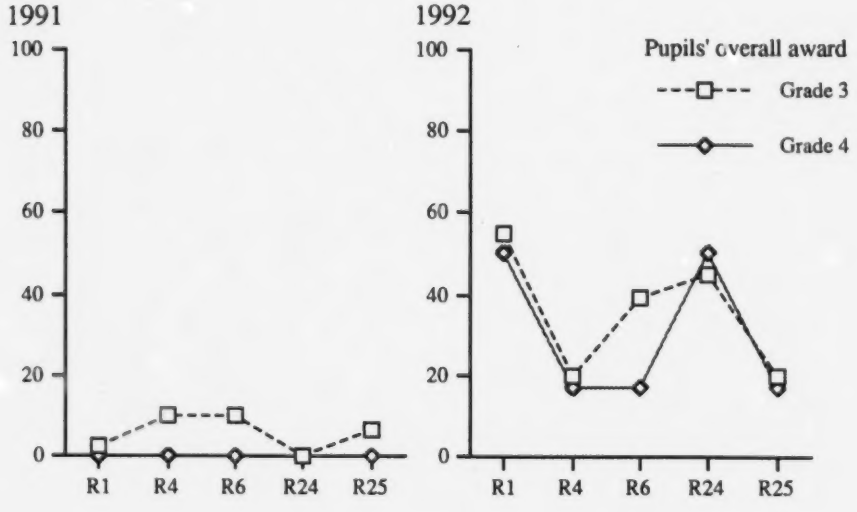


Table 3.16 Percentage of pupils successful in the criteria available in 1991

	Grades	
1991	3	4
R9	44	25

Patterns over the two years

The patterns of attainment across the two years show distinct differences. In 1991 taking both groups of candidates together, R1 and R24 proved attainable by the least number of candidates. In 1992 the position was completely reversed.

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

None of the criteria in this set were attained by over 80% of pupils awarded either grade 3 or grade 4.

General Level criteria (Interpreting a task)

The following nine criteria were available at General Level in the category Interpreting a task in both 1991 and 1992.

R1 Solve problems involving excess information

R4 Simple equations

R6 Create a simple relationship in symbols

Other criterion available in one year only:

R25 Decide the steps and their order in a non-routine problem (1992)

Figure 3.14 shows the results for criteria available in both 1991 and 1992. Table 3.17 shows the percentage of candidates successful in criteria which were only available in one year.

Figure 3.14 Percentage of pupils successful at General Level competences in Interpreting a task

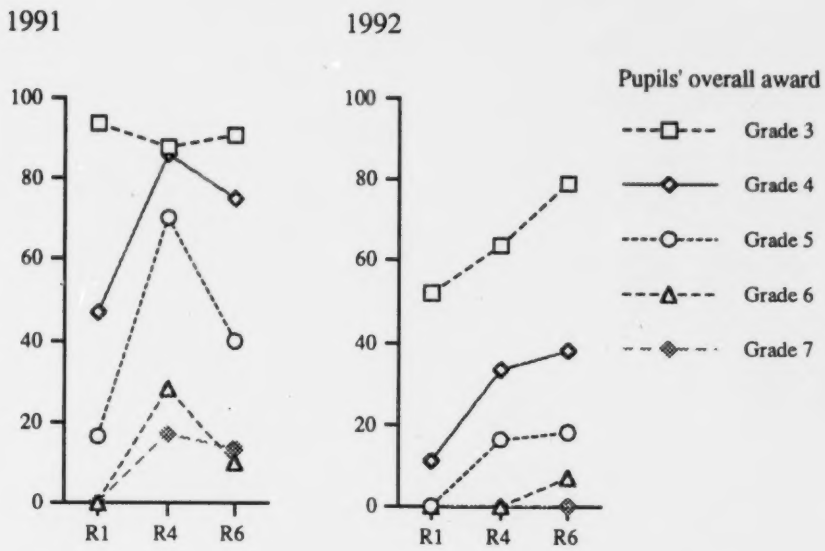


Table 3.17 Percentage of pupils successful in criteria available in one year only

	Grades				
1992	3	4	5	6	7
R25	41	3	0	0	0

Patterns over two years

The relative pattern of difficulty remains constant in each year, i.e. for each criterion the number of successful pupils falls as the grades decrease. For pupils at every grade, the questions related to the criteria in the 1992 examination appear to be more difficult than the questions in 1991.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
R1	Solve problems involving excess information	Yes	-	-	-	-
R4	Simple equations	Yes	Yes	-	-	-
R6	Create a simple relationship in symbols	Yes	-	-	-	-
R25	Decide the steps and their order	-	-	-	-	-

Significant differences between grades 4 and 5

R1 (1991)	Solve problems involving excess information
R4 (1992)	Solve simple equations
R6 (1991 and 1992)	Create a simple relationship in symbols

Foundation Level criteria (Interpreting a task)

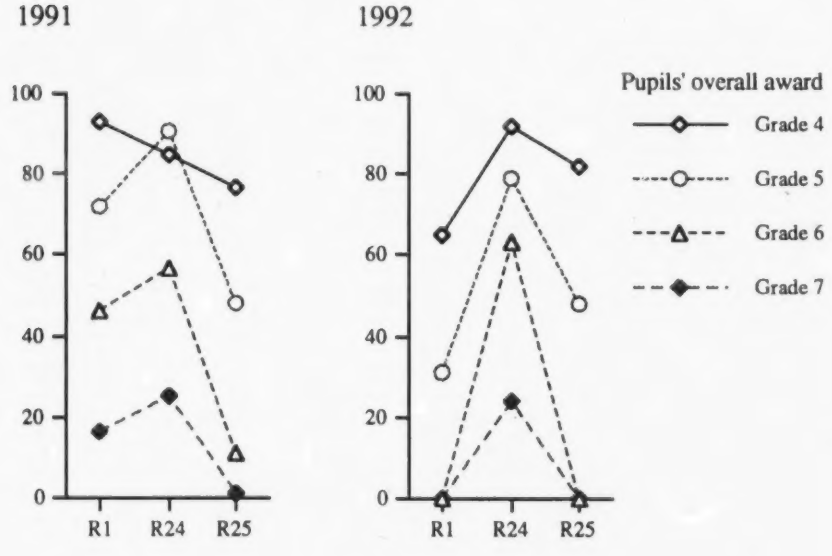
The following criteria were available at Foundation Level in the category Reasoning and Applications (Interpreting a task) in both 1991 and 1992.

R1	Solve problems involving 2/3 straightforward sources
R24	Make simple deductions from 2 or 3 given facts
R25	Decide the steps (2/3) and their order in non-routine problems

No other criteria were available in one year only.

Figure 3.15 shows the results for those criteria available in both 1991 and 1992.

Figure 3.15 Percentage of pupils successful at Foundation Level competences in Interpreting a task



Patterns over two years

Apart from R1, where far fewer students at all grade levels are successful in 1992, the pattern over the two years is similar. The relative difficulty of individual criteria within the set of criteria remains more or less constant over the two years.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
R1	Solve problems involving 2/3 sources	Yes	-	-	-
R24	Make simple deductions from 2 or 3 given facts	Yes	Yes	-	-
R25	Decide the steps (2/3) in non-routine problems	Yes	-	-	-

Significant differences between grades 4 and 5

R1 (1991, 1992) Solve problems involving 2/3 sources

R25 (1991, 1992) Decide the steps (2/3) in non-routine problems

Reasoning and Applications (Doing a task)

Credit Level criteria

No criteria were available at Credit Level in both years from this category. In 1991 only, four criteria were included:

- R10 Prove/disprove a conjecture
- R11 Try a special case
- R20 Continue complex patterns
- R22 Use symbols to make a conjecture about the general pattern

Table 3.18 shows the percentages of successful candidates.

Table 3.18 Percentage of pupils successful at Credit Level in Doing a task

	Grades	
1991	3	4
R10	0	0
R11	2	0
R20	80	75
R22	35	16

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4
R10	Prove/disprove a conjecture	-	-
R11	Try a special case	-	-
R20	Continue complex patterns	Yes	-
R22	Use symbols to make a conjecture about a general pattern	-	-

General Level criteria (Doing a task)

Four criteria were available in both years at General Level in the sub-set of Reasoning and Applications (Doing a task).

R15 Produce an organised list

R20 Continue patterns

R22 Generalise features of a pattern

R23 Recognise shapes with line and rotational symmetry

One other criterion was available in 1992:

R21 Extend simple patterns

Figure 3.16 shows the results for criteria available in both 1991 and 1992. Table 3.19 shows the percentage of successful candidates in the criterion available in 1992 only.

Figure 3.16 Percentage of pupils successful at General Level competences in Doing a task

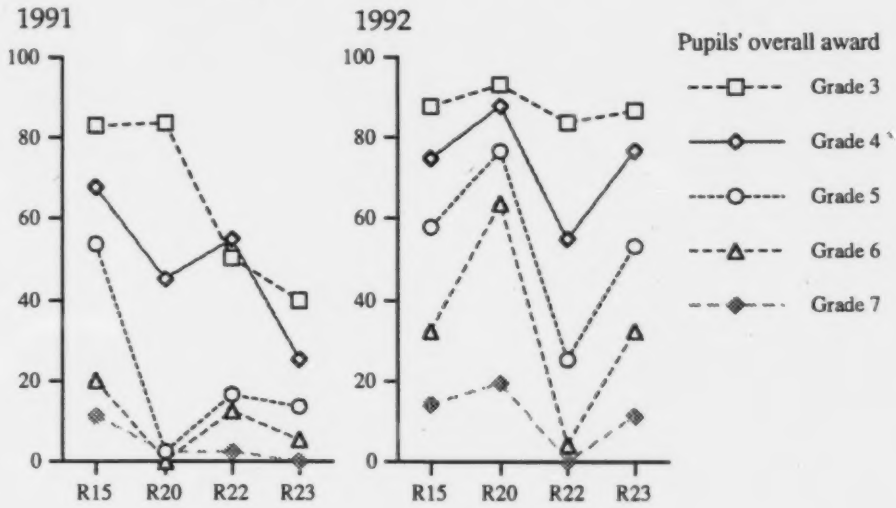


Table 3.19 Percentage of pupils successful in criteria available in one year only

	Grades				
1992	3	4	5	6	7
R21	64	50	0	0	0

Patterns across two years

Apart from grades 3 and 4 at R22, there is a consistent pattern of decreasing numbers of pupils being sucesssful as the grades decrease. The relative difficulty of criteria across the two years differs. All grades have more difficulty with R20 in 1991 than 1992.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
R15	Produce an organised list	Yes	-	-	-	-
R20	Continue patterns	Yes	Yes	-	-	-
R21	Extend simple patterns	-	-	-	-	-
R22	Generalise features of a pattern	Yes	-	-	-	-
R23	Recognise line and rotational symmetry	Yes	-	-	-	-

Significant differences between grades 4 and 5

R15 (1992)	Produce an organised list
R20 (1991 and 1992)	Continue patterns
R22 (1991 and 1992)	Generalise features of a pattern
R23 (1992)	Recognise line and rotational symmetry

Foundation Level criteria (Doing a task)

Only one criterion was available in both 1991 and 1992 at Foundation Level in this subset of Reasoning and Applications.

R20 Continue simple patterns

Other criteria available in one year only

R14 Draw the situation (1991)
R16 Look for a pattern (1991)
R17 Guess, check and improve (1992)
R21 Extend simple number patterns (1991)

Table 3.20 shows the results for the criterion available in both years.

Table 3.21 shows the results for the criteria available in one year.

Table 3.20 Percentage of pupils successsful at Foundation Level competences in Doing a task

	Grades			
R20	4	5	6	7
1991	99	98	93	88
1992	96	99	87	61

Table 3.21 Percentage of pupils successsful in criteria available in one year only

	Grades			
1991	4	5	6	7
R14	44	22	2	11
R16	76	67	43	18
R21	83	62	39	19

	Grades			
1992	4	5	6	7
R17	86	77	52	17

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	4	5	6	7
R14	Draw the situation (1991)	-	-	-	-
R16	Look for a pattern (1991)	-	-	-	-
R17	Guess, check and improve (1992)	Yes	-	-	-
R20	Continue simple patterns	Yes	Yes	Yes	Yes
R21	Extend simple number patterns (1991)	Yes	-	-	-

Significant differences between grades 4 and 5

There were no significant differences in this group of criteria.

Reasoning and Applications (Completing a task)

Credit Level criteria

Only one criterion was available at Credit Level in the subset 'Completing a task' in both 1991 and 1992.

R7 Explain the solution in general terms displaying awareness of overall strategy

A further three criteria were available in 1991 only:

R2 Interpret a solution in the context of the problem

R3 Reject invalid solutions

R8 Explain the solution clearly highlighting important factors

Table 3.22 shows the results for the criterion available in both years.

Table 3.23 shows the results for the criteria available in one year only.

Table 3.22 Percentage of pupils successful at Credit Level in Completing a task

	Grades	
R7	3	4
1991	30	16
1992	0	0

Table 3.23 Percentage of pupils successful on criteria available in one year only

	Grades	
1991	3	4
R2	44	8
R3	5	0
R8	17	8

Grade Competences

(criteria attained by over 80% of pupils achieving a grade)

No criteria in this subset were attained by over 80% of grade 3 or grade 4 candidates.

General Level criteria (Completing a task)

Two criteria were available at General Level for 'Completing a task' in both 1991 and 1992.

R3 Reject inappropriate results

R7 Explain solution in general terms

Other criteria available in one year only:

R2 Interpret solution in the context of the problem (1991)

R8 Set out the solution in organised steps (1991)

Figure 3.17 shows the results for criteria available in 1991 and 1992. Table 3.24 shows the percentage of candidates successful in criteria available in one year only.

Figure 3.17 Percentage of pupils successful at General Level competences in Completing a task

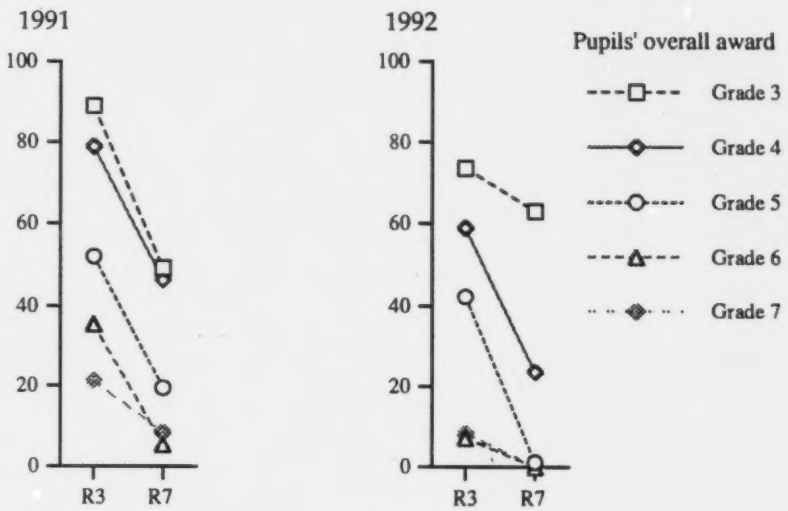


Table 3.24 Percentage of pupils successful in criteria available in one year only

	Grades				
1991	3	4	5	6	7
R2	83	41	8	0	0
R8	96	92	48	18	8

Patterns over two years

The relative difficulty of the two criteria was maintained across both years with R7 - explain a solution in general terms, being more difficult for all grades than R3 - reject inappropriate results.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

	Grade	3	4	5	6	7
R2	Interpret solution in the context of the problem	Yes	-	-	-	-
R3	Reject inappropriate results	Yes				
R7	Explain solution in general terms	-	-	-	-	-
R8	Set out the solution in organised steps	Yes	Yes	-	-	-

Significant differences between grades 4 and 5

R2 (1991)	Interpret solution in the context of the problem
R3 (1992)	Reject inappropriate results
R7 (1991 and 1992)	Explain solution in general terms
R8 (1991)	Set out the solution in organised steps

Foundation Level criteria (Completing a task)
Only one criterion was available in both 1991 and 1992.

R7 Explain solution with reference to specific values

Other criteria available in 1992 year only:

R2 Interpret results with reference to problem

R3 Reject results which do not fit the constraints of the problem

Tables 3.25 and 3.26 show the percentages of successful candidates.

Table 3.25 Percentage of pupils successful at Foundation Level competences in Completing a task

	Grades			
R7	4	5	6	7
1991	74	37	7	3
1992	90	67	16	3

Table 3.26 Percentage of pupils successful in criteria available in one year only

	Grades			
1992	4	5	6	7
R2	80	75	47	22
R3	93	77	41	22

Patterns over two years
At grades 4 and 5 slightly more pupils were successful at R7 - explaining the solution with reference to specific values - in 1992 than in 1991. In both years the pattern of difficulty was maintained, with the numbers of successful pupils decreasing with grade.

Grade Competences
(criteria attained by over 80% of pupils achieving a grade)

		Grade	4	5	6	7
R2	Interpret results with reference to the problem		Yes	-	-	-
R3	Reject results which do not fit the constraints of the problem		Yes	-	-	-
R7	Explain solution with reference to specific values		Yes	-	-	-

Significant differences between grades 4 and 5
R2 (1992) Interpret results with reference to problem

R7 (1991) Explain solution with reference to specific values

Mathematical competences at grades 3, 4, 5 and 6

A full list of 'grade competences' for each level was given at the end of each section including those where competence was demonstrated in one year only. This section provides a summary of the competences demonstrated by at least 80% of candidates in both 1991 and 1992.

Grade 3 Competences (Credit/General Level)

Credit Level

Number

K22 Select steps for routines (e.g. joint variation)

K28 Calculate cumulative compound interest

General Level

Number

K7 Read instruments using interpolation

Measure

K18 Calculate the circumference of a circle

Shape

K15 Solve right angled triangles using trigonometric ratios

Information Handling

K10 Construct graphs when the scale is not given

Interpreting a task

R6 Create a simple relationship in symbols

Doing a task

R15 Produce an organised list (find all)

R20 Continue patterns

Grade 4 Competences (General/Foundation Level)

General Level

Number

K7 Read instruments using interpolation

Foundation Level

Number

K7 Read instruments with straightforward scales

K22 Select correct arithmetic operation

K23 Select steps for direct proportion

K27 Calculate using four rules with whole numbers and decimals

K28 Calculate simple percentage of a quantity

K29 Money calculations

Measure

K4 Interpret scale drawings with scales expressed in words

K21 Calculate the volume of a cube or cuboid

Shape

K9 Recognise 3D shapes - cube and cuboid

Information Handling

K1 Interpret simple tables (up to three categories of data)

K32 Calculate averages

Interpreting a task

R24 Make simple deductions from 2 or 3 given facts

R25 Decide the steps (2/3 only) and their order in non routine problems

Doing a task

R15 Produce an organised list (given some find others)

R20 Continue simple patterns

Grade 5 Competences (General/Foundation Level)

General Level

Number

K7 Read instruments using interpolation

Foundation Level

Number

K7 Read instruments with straightforward scales

Measure

K4 Interpret scale drawings with scales expressed in words

Shape

K9 Recognise 3D shapes - cube and cuboid

Information Handling

K32 Calculate averages

Interpreting a task

R24 Make simple deductions from 2 or 3 given facts

Doing a task

R15 Produce an organised list (given some find others)

R20 Continue simple patterns

Grade 6 Competences (General/Foundation Level)

General Level

No competences at General Level

Foundation Level

Shape

K9 Recognise 3D shapes - cube and cuboid

Reasoning and Applications: Doing a task

R15 Produce an organised list (given some find others)

R20 Continue simple patterns

The number of criteria in which candidates demonstrated success fell as the grade level fell. In no case was there a criterion which was successfuly attained by a lower grade which was not also attained by a higher grade.

At grade 3, the grade competences in General Level criteria were spread across a range of outcomes - Number, Measure, Shape, Information Handling, Interpreting a task and Doing a task. At Credit Level, Number was the only category where this level of success was recorded. No criteria within Relationships at either Credit or General Level were attained by over 80% of pupils in both 1991 and 1992

At grade 4, a similar picture emerges in relation to the lower levels. Only one criterion from Number is included as a grade competence at General Level. Apart from Relationships, grade level competences are demonstrated in all other categories at Foundation Level.

The same criterion for Number at General Level is also a grade competence for grade 5 candidates and again the competences at Foundation Level are spread across all categories except Relationships. In this case there are fewer grade competences within each category.

At grade 6 the only competences are at Foundation Level within the categories Shape and Doing a task.

Significant differences between Grades 4 and 5

The boundary between Foundation Level and General Level is of crucial importance when trying to ensure that lower attaining students gain the highest award possible. Over the past few years in the Standard Grade Mathematics examination there has been a peak of attainment at grade 5. Being aware of those criteria which discriminate highly between grades 4 and 5 may provide the information that teachers need as a focus for helping students overcome the hurdle between the levels.

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Criteria at both General and Foundation Levels show significant differences between grade 4 and 5 and both are reported at the end of each section in this chapter. In this summary only the criteria which were significant in both 1991 and 1992 are listed.

General Level

Measure

K4 Interpret scale drawings (scale as ratio or scaled line)
K18 Calculate the circumference of a circle

Relationships

K24 Solve simple equations

K31 Evaluate formulae in symbols

Shape

K15 Solve right angled triangles using trigonometric ratios

Interpreting a task

R6 Create a simple relationship in symbols

Doing a task

R20 Continue patterns

R22 Generalise features of a pattern

Reasoning and Applications: Completing a task

R7 Explain solutions in general terms

Foundation Level

Shape

K15 Calculate the third angle of a triangle

Interpreting a task

R1 Solve problems involving 2/3 straightforward sources

R25 Decide the steps (2/3 only) and their order in non routine problems

The significant differences at General Level tend to focus on these criteria which depend on symbolism and which demand a level of generalisation. At Foundation Level, two criteria which relate to the ability to interpret a problem are also indicators of attainment at the higher level. Focusing on these areas might help to boost the grades of borderline pupils.

4 Classroom Work

Introduction

The second aim of the study was to describe the competences shown in school work by pupils failing to achieve at least a grade 6 in Standard Grade Mathematics. Because of the difficulty of identifying these pupils in advance of the examination, teachers were asked to select pupils who were likely to be awarded grade 5, 6 or 7.

Selecting the sample

In collaboration with the SEB, six large schools were selected from across Scotland as likely to provide a reasonable sample of low attaining pupils. Teachers in these schools all indicated their willingness to be involved and discussions were held to select a group of about twelve S4 pupils in each school for further study. In an attempt to minimise the complication that some pupils might fail to achieve for behavioural rather than cognitive reasons, teachers were asked to choose pupils who were regular attenders and likely to complete the course, i.e. to sit the 1992 examination.

The profile of competences

The same framework which was used to analyse the examination scripts was used to create a profile of competence for each pupil. For our work in schools where our interest was only in low attaining pupils, the profile was prepared covering Foundation and General Level criteria only.

A major difficulty arises in making direct decisions about grade levels in mathematics since the EGRC are not written at all six grades. Statements of criteria are written at three levels only: Foundation, General and Credit. Decisions about whether the final award is at the upper or lower grade of each level depends on a system of cut-off scores. Teachers also use cut-off scores to estimate grade levels. Our conclusions about what pupils can or cannot do are based on those statements of criteria which form the profile of competences.

School characteristics

The six schools were drawn from five different regions. They were all large schools with between 900 and 1200 pupils. In four schools the pupils selected for study were drawn from a single class. In the other two schools, pupils were divided between two classes. The classes tended to be small (less than 15 pupils), and in all but one school one teacher was responsible for each class. Some of the teachers had responsibilities beyond the mathematics department. Only in one case was the teacher

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a full-time promoted member of the mathematics department. Table 4.1 summarises the characteristics of the six schools

Table 4.1 Characteristics of schools

School	School size	Classes visited	Class size	Teacher	Status of teacher
A	1100	1	15	1 per class	Full-time maths
B	1000	2	15	1 per class	Full-time maths AHT
C	1200	1	15	1 per class	Full-time maths
D	900	1	12	2 per class	Full-time maths Maths/guidance
E	900	1	12	1 per class	APT maths
F	1200	2	12/15	1 per class	DHT + AHT

Class organisation

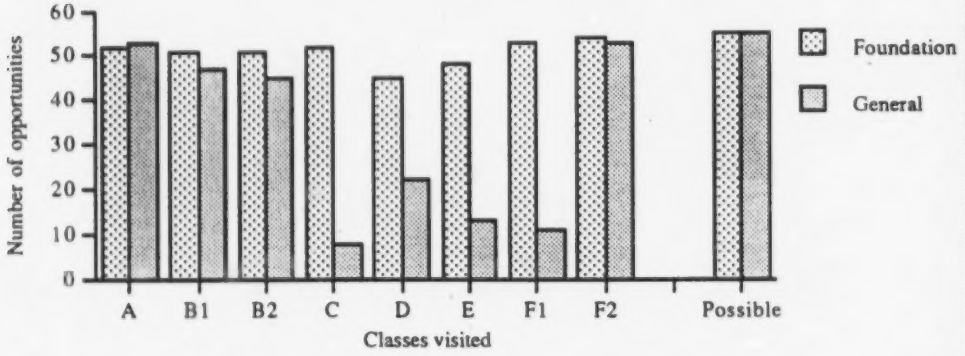
It had been one of our concerns that if departments were using mixed ability grouping, tracking twelve low attaining pupils might prove logistically difficult. In fact this was an unfounded concern as all the departments with which we were involved set their pupils to some extent. In four of the classes we visited, the pupils were in Foundation/General Level classes. The remaining four were in Foundation Level classes. Most Foundation Level classes did allow pupils the opportunity to work on some General Level criteria, but only those which followed on sequentially from Foundation Level tasks. For example, K14 (General) - Construct formulae in symbols to describe a given relationship - has no equivalent at Foundation Level and was omitted by six of the eight classes.

Where the work of the class was restricted mainly to Foundation Level criteria, this was done for what were considered to be sound educational reasons. These pupils were having great problems with mathematics, so it seemed more profitable to give them the maximum support in small classes where they could concentrate on a narrower range of mathematical knowledge and skills.

As part of the profile of attainment on each pupil, teachers were asked to indicate which of the criteria had been offered to pupils. In each class the same opportunities had been provided for all or most pupils. Figure 4.1 shows how the opportunities offered compare with the possible number of opportunities which could have been available from the full profile of Foundation and General Level criteria. Not all criteria are written as statements of performance at both levels. Fifteen of the criteria on the profile are written at Foundation Level only, another fifteen are

written at General Level only and the remainder (forty) are written at both levels. This means that a course could be devised consisting of 55 Foundation Level criteria and 55 General Level criteria. The classes which offered all the opportunities as set out in the profile are in school A and school F2. By contrast, schools C, E and F1 have concentrated almost entirely on criteria written at Foundation Level.

Figure 4.1 Number of opportunities offered to the classes visited



This difference in the opportunities offered to pupils complicated the task of analysing what pupils can do. There must be a distinction between those who do not show evidence of attaining a criterion when given the opportunity and those who are not given the opportunity.

Teaching materials

All schools use a variety of textbooks with their classes. These texts were supplemented by teacher-prepared worksheets to cater for perceived gaps or for additional practice. Over the six schools 20 different textbooks were in use:

Central Mathematics	Foundation in Maths/Books 1-3
Mathswise	Maths Matters/Books 1 - 6
SMP Maths/Books G6, G7	Every Day Maths Practice
Foundation Mathematics	Maths for You/Books 1, 2
Headway Maths/Books 3, 4, 5	

In one particular school we had to refer to material from twelve different texts and additional photocopied worksheets in order to analyse pupils' written work. In all schools, pupils did not have their own copies of texts but obtained them each day as needed. They could be available for homework.

Where departments provided us with a summary of their Standard Grade courses which showed how decisions were made about which textbooks to use, the texts were categorised by content area and level of difficulty. For example, one text would be recommended for percentages at Foundation Level and another for graphs at General Level. This is in line with the advice given in *Standard Grade Revised Arrangements in*

Mathematics where a Checklist of Content is provided 'to assist teachers in selecting material for courses at each level'. How easy it is to translate this content categorisation into the skills needed to attain the EGRC is debatable. While there is considerable overlap between content and 'Knowledge and Understanding', the relationship of content to 'Reasoning and Applications' is far less clear. An analysis of each textbook in terms of how it meets the EGRC of 'Reasoning and Applications' would be very useful to teachers trying to provide opportunities for pupils to develop and practise these skills. An additional problem which can affect teachers' ability to provide a flexible course for pupils is that not all the criteria for Foundation and General Level seem to be available from one source.

Teaching styles

At the time the school visits took place, the pupils were involved in revision work, practising past papers or completing investigations. There was, therefore, no teaching of new material. The following comments on teaching styles are, therefore, limited in the extent to which they might apply to teaching at earlier stages of the course.

All classes were taught as a single unit. The general pattern was for some teacher exposition and reminder of previous work, examples on the board with questions and discussion to aid understanding and then individual work by pupils on the same area. Teachers spent the remainder of the time supporting those who needed or asked for help.

The classes were small enough for the teacher to talk to each pupil individually, and to provide support and guidance. The line between support and 'spoon feeding' is fine. At least two of the teachers referred to this as a problem. They wanted to provide the maximum support and guidance while encouraging pupils, where possible, to develop their own thinking. Whereas supportive teaching involves asking probing questions and providing prompts towards a solution, 'spoon feeding' simply supplies the solution or the method. Some pupils made no attempt to think for themselves and asked the teacher or their peers for help at every step.

Teachers generally expressed concern about absenteeism, the consequent difficulties of progression and continuity and the lack of motivation for many pupils. They recognised that most of the pupils in the class had a long history of failing in mathematics and expressed frustration with those pupils whom they felt could perform better but who had long since given up. The pressure of the Standard Grade examination provided external motivation for some but not for others.

Any thorough examination of teaching styles with low attaining pupils would obviously involve a much longer exposure to classroom teaching with systematic and focussed observation of the interaction between pupil and teacher. The lessons learned from such a study might be beneficial in providing guidelines for teachers on how best to cater for this particular group of pupils.

Collecting the data

Information on the attainments of pupils was collected from a number of sources. For each pupil we were trying to complete, as far as possible, a profile of attainment drawn from three sources - researchers, teachers and examination performance. Researchers visited the schools, sat in with pupils during mathematics classes, analysed written work and collected teachers' estimates on pupil attainment on each of the criteria in the profile. Finally the examination performances of these pupils were analysed in the 1992 Standard Grade Mathematics papers.

Observation in class

Although we observed in the classroom for 3 or 4 days, what could be observed was very limited in terms of completion of the overall profile. At the start of each class, or beforehand if that was feasible, researchers analysed the content of the relevant section of the textbook or Standard Grade past paper and noted the criteria likely to be observed during the course of the lesson. These criteria were then used as a checklist to be completed for each pupil as far as possible. For example, in one class pupils were working on interpreting and completing wage slips. The criteria which could be observed during this 55 minute lesson were identified as

- extracting information from a table (K1)
- completing a table (K12)
- carrying out money calculations (K29)

Perhaps paradoxically when pupils were revising past papers a wider range of criteria could be observed in any one teaching period and researchers could take the opportunity to talk to pupils about a wider range of skills.

Written work

During the remainder of the school visiting days, we collected from pupils and teachers all written work relating to mathematics. This included as many jotters as were available together with completed Investigations.

One of the difficulties with analysing written work in jotters lies in knowing what was asked of the pupils. A list of answers by itself is not helpful. Textbooks were collected from teachers to help match completed exercises to tasks. Fortunately most pupils had been trained to head their work with topic titles. The task was also made feasible by the fact that pupils in the same class tended to work through the same set of tasks in the same order.

Evidence of attainment with respect to each criterion was sought in the written work. As evidence was found two pieces of data were entered in the profile. The first related to the opportunity to meet the criterion and the other to success or failure. Once all the information had been collected it was then possible to make a decision about success by

considering the proportion of successes to opportunities. Some criteria occurred more frequently than others making it difficult to have a uniform cut-off score for success.

It had become clear during classroom observations that researcher analysis of completed written work was likely to show a higher level of attainment than teacher evidence. The interaction of teachers and pupils in the classrooms means that written work which is completed tends to be done with the maximum support, and perhaps more than just support, from the teacher and other pupils. This has a direct bearing on the differences between teacher and researcher assessment which were discussed in Chapter Two.

Teacher estimates

Copies of the same profiles being completed by researchers for each pupil were also supplied to the class teacher. Teachers were asked to indicate which of the various criteria had been offered to pupils in the class and to indicate attainment against each criterion. They were also asked to provide an overall estimate for each element. We had indicated to teachers that our interest in the classroom was in low attaining pupils, especially those who would fail to gain a grade 6. The final breakdown of estimated grades is shown in Table 4.2.

Table 4.2 Estimated awards for selected pupils

Grade level	KU	RA
5	30	17
6	29	35
7	14	21

Results of classroom study

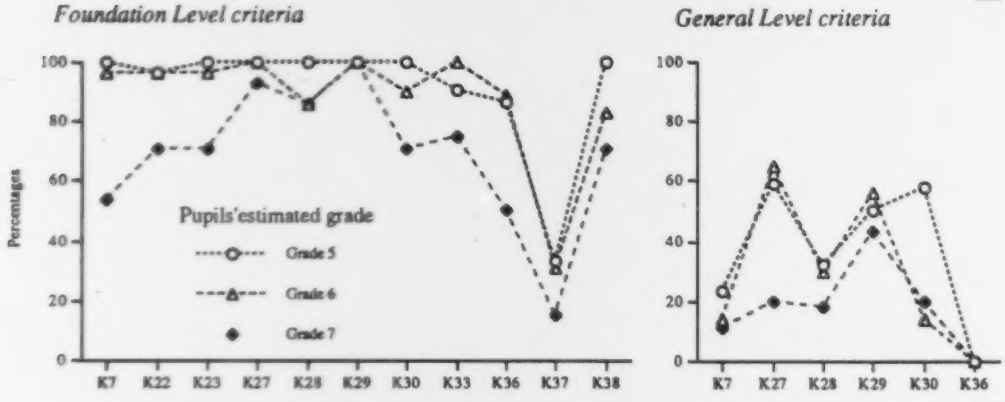
The criteria from the profile have been presented under the same eight headings as those used for reporting the examination results i.e. Number, Measure, Relationships, Shape, Information Handling, Interpreting the task, Doing the task and Completing the task. Each graph shows the competences of those pupils who are estimated by their teachers as capable of attaining grade 5, 6 or 7. Grades were estimated separately for Knowledge and Understanding and Reasoning and Application. The figures used to draw the graphs are calculated from the percentage of pupils who had the opportunity to demonstrate success. Foundation Level criteria were covered by all or most pupils. However, many of the criteria written at General Level were offered to very few or no pupils. These have been omitted from the analysis.

The findings are presented with Foundation and General Level criteria side by side. Criteria which were successfully attained by over 80% of those pupils whom teachers estimated would not attain a grade 6 (i.e. grade 7) are highlighted.

Number

A total of 11 criteria relating to number were available for inspection at Foundation Level and a further eight at General Level. In some instances the criterion is only written at one level and this is indicated in the listing. As referred to earlier, some General Level criteria were not available to students and these criteria are marked with an asterisk and omitted from the analysis.

Figure 4.2 Percentage of pupils successful in the classroom (Number)



	Foundation	General
K7	Read straightforward scales	Use interpolation to read scales
K8	Nothing at this level	Read negative numbers on scales*
K22	Select arithmetic operation	Nothing at this level
K23	Select steps for direct proportion	Select steps for inverse proportion*
K27	Calculate using 4 rules	Add and subtract integers
K28	Calculate simple % of quantities	Express one quantity as % of another
K29	Money calculations (VAT, wages)	Money calculations (premiums)
K30	Round to nearest unit	Round to required number of D.P.
K33	Calculate duration of time	Nothing at this level
K36	Approximate calculations (+, -, x)	Approximate calculations (4 rules)
K37	Equivalences metric/imperial units	Nothing at this level
K38	Convert units (length, weight)	Convert units (area, volume)

Competences of pupils estimated to be classified as grade 7

For those pupils who were estimated by their teachers to be grade 7 in Knowledge and Understanding, the following Foundation Level criteria were attained in classwork by more than 80% of all students.

K27 Calculate using 4 rules with whole numbers and decimals

K28 Calculate simple % of quantities

No General Level criteria were attained by over 80% of pupils estimated to be classified grade 7.

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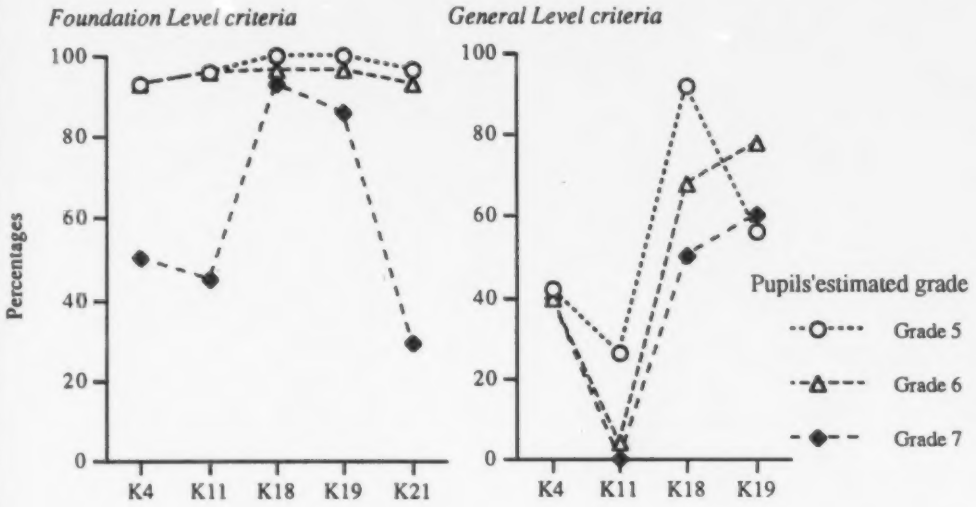
Measure

A total of six criteria relating to measure were available at Foundation Level and/or General Level. The General Level criteria marked with an asterisk were not available to most students estimated to attain Grade 7 and were omitted from the analysis.

Figure 4.3 Percentage of pupils successful in the classroom (Measure)



	Foundation	General
K4	Interpret simple scale drawings	Interpret scale drawings (scale as ratio)
K11	Construct scale drawings	Construct scale drawings (scale not given)
K18	Perimeter of rectilinear figures	Circumference of circle
K19	Area of rect., square, triangle	Area of kite, parm., rhombus, circle
K20	Nothing at this level	Surface area of cube, cuboid, cylinder *
K21	Volume of cube, cuboid	Volume of cylinder, triangular prism*

Competences of pupils estimated to be classified as grade 7

At Foundation Level two criteria were attained by over 80% of pupils estimated to attain grade 7 in Knowledge and Understanding

K18 Calculate perimeter of rectilinear figures

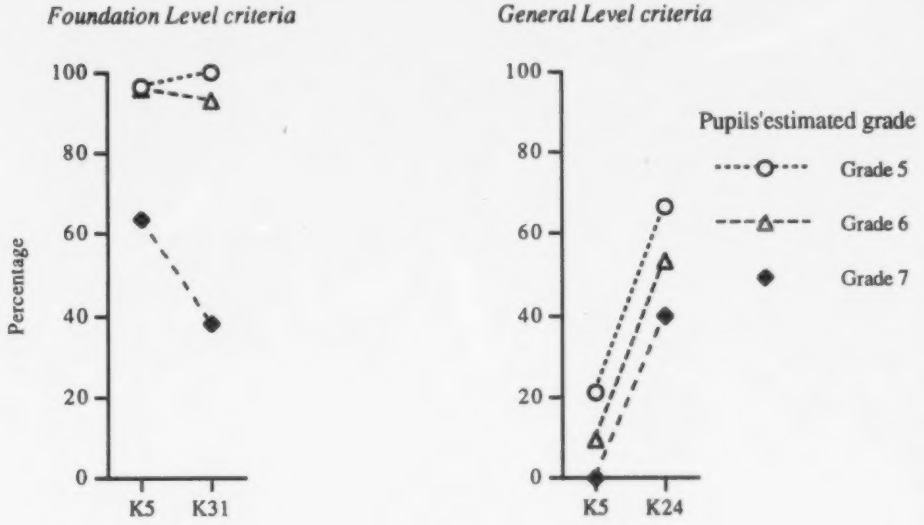
K19 Calculate area of rectangle, square or right-angled triangle

Two related General Level criteria i.e. calculate circumference of circle (K18) and calculate area of kite, parallelogram, rhombus and circle (K19) were attained by over 50% of these pupils. No General Level criteria were attained by over 80%.

Relationships

A total of seven criteria on Relationships were available at Foundation Level and/or General Level. The General Level criteria marked with an asterisk were not available to most students estimated to attain grade 7 and were omitted from the analysis.

Figure 4.4 Percentage of pupils successful in the classroom (Relationships)



	Foundation	General
K5	Identify trend in line graph	Identify changes of features in line graph
K6	Nothing at this level	Know that y = ax+b is a straight line*
K14	Nothing at this level	Construct formulae in symbols*
K24	Nothing at this level	Solve simple equations
K26	Nothing at this level	Solve simple inequations*
K31	Evaluate formulae in words	Evaluate formulae in symbols*
K34	Nothing at F level	Collect terms, brackets, common factors*

Competences of pupils estimated to be classified as grade 7

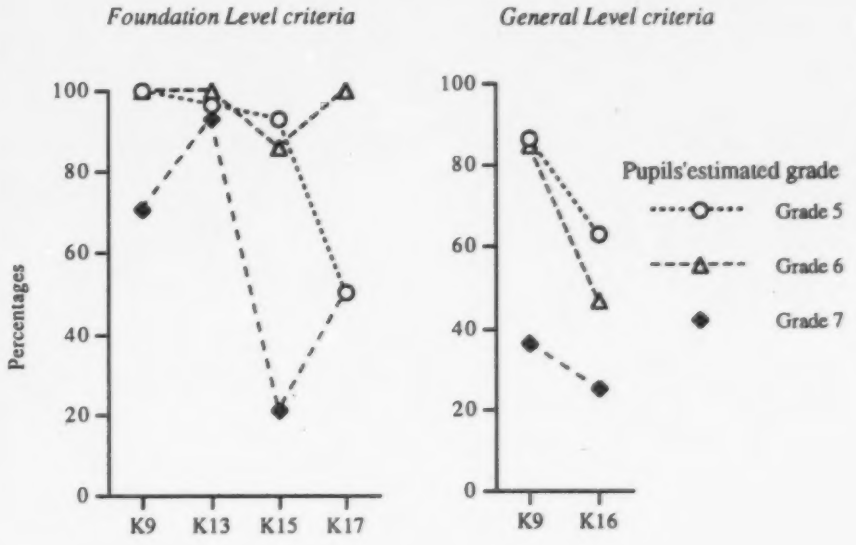
No criteria were achieved by over 80% of pupils estimated to attain grade 7 at either Foundation or General Level. K 5 at Foundation Level which required pupils to identify the trend in a line graph where there is one main trend - was the criterion attained by most of the lowest attaining pupils.

Almost all the criteria which involve work with symbols appear only at General Level. These are, in many cases, the criteria which discriminate well between Foundation and General Level candidates in the examinations. Teachers clearly do not consider it worthwhile to spend time in the classroom on these criteria for pupils operating at the lowest levels of attainment.

Shape

A total of five criteria on Shape were available at Foundation Level and / or General Level. The General Level criteria marked with an asterisk were not available to most students estimated to attain grade 7 and were omitted from the analysis.

Figure 4.5 Percentage of pupils successful in the classroom (Shape)



	Foundation	General
K9	Recognise 2D drawing as cube, cuboid	Recognise complex shapes
K13	Co-ordinates in first quadrant	Co-ordinates in all four quadrants*
K15	Calculate third angle in triangle	Solve right angled triangles*
K16	Nothing at this level	Use Theorem of Pythagoras
K17	Supplementary, complementary angles	Nothing at this level

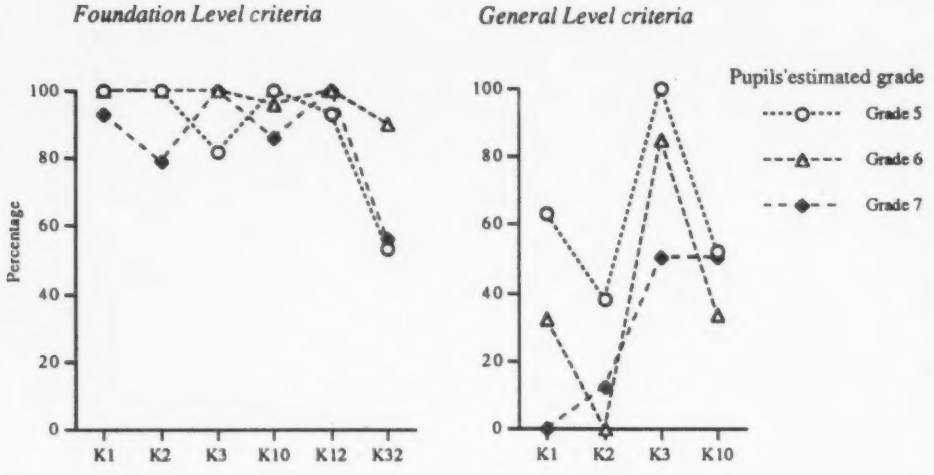
Competences of pupils estimated to be classified as grade 7

One criterion, K13 - the ability to plot or determine co-ordinates in the first quadrant - was attained by over 80% of the lowest attaining pupils in classwork at Foundation Level. These students were not, however, offered the opportunity to plot points in four quadrants.

Information Handling

A total of six criteria were available in Information Handling at either Foundation and/or General Level. All criteria at both Foundation and General Level within this category were available to most students.

Figure 4.6 Percentage of pupils successful in the classroom (Information Handling)



	Foundation	General
K1	Interpret simple tables	Tables with up to 5 categories of data
K2	Interpret graphs with simple scales	Graphs with interpolations.
K3	Interpret pie chart (largest/smallest)	Interpret pie chart (by proportion)
K10	Complete simple graphs	Construct graphs, scale not given
K12	Complete a table	Nothing at this level
K32	Calculate averages	Nothing at this level

Competences of pupils estimated to be awarded grade 7

At Foundation Level pupils estimated to be classified as grade 7, were successful on a number of criteria within Information Handling. These were

K1 Extract information from simple tables with 2/3 categories including timetables and ready reckoners

K2 Interpret graphs with straightforward scales.

K3 Interpret pie chart identifying largest and smallest sectors

K10 Complete graphs given the scale in words and the structure

K12 Complete a table

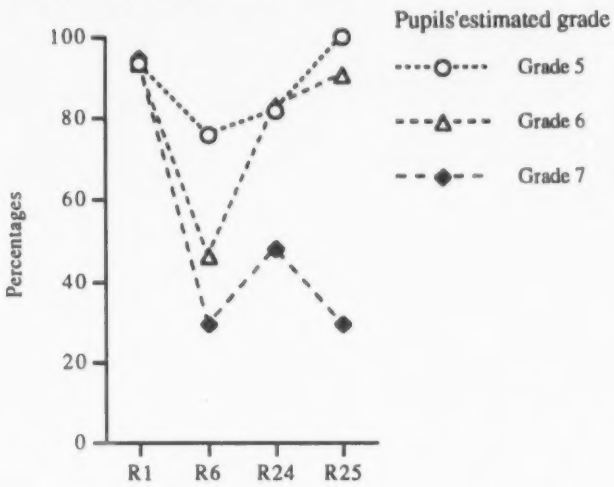
None of the General Level criteria were attained by over 80% of pupils estimated to be grade 7.

Interpreting a task

The criteria within Reasoning and Applications have been sub-divided under three headings. For Interpreting a task four criteria were offered at Foundation Level and only one at General Level to grade 7 students.

Figure 4.7 Percentage of pupils successful in the classroom (Interpreting a task)

Foundation Level criteria



	Foundation
R1	Interpret a problem using 2/3 sources
R6	Create formula in words
R24	Make simple deductions
R25	Decide the steps and their order

General Level criterion

	Grades		
Class	5	6	7
R1	38	31	19

	General
R1	Interpret a problem containing excess information

Competences of pupils estimated to be classified as grade 7

One criterion at Foundation Level was attained by over 80% of pupils estimated to be awarded grade 7

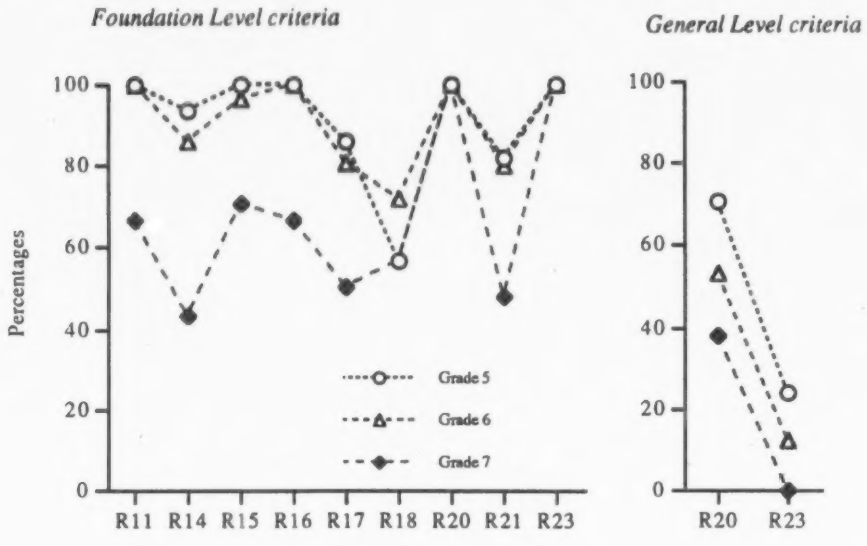
R1 Interpret a problem using 2/3 sources (statements and diagrams)

It is worth noting that this criterion was the only one extended to General Level for most students.

Doing a task

Ten criteria were offered to pupils at Foundation Level in Doing the task. Two of these were also offered at General Level. The General Level criteria marked with an asterisk were not available to most students estimated to attain grade 7 and were omitted from the analysis.

Figure 4.8 Percentage of pupils successful in the classroom (Doing a task)



	Foundation	General
R11	Experiment	Experiment in an informed way*
R14	Draw the situation	Nothing at this level
R15	Produce an organised list	Produce an organised list (find all)*
R16	Look for a pattern	Nothing at this level
R17	Guess, check and improve	Nothing at this level
R18	Make a conjecture and test	Nothing at this level
R20	Continue simple patterns	Continue patterns
R21	Extend simple number patterns	Extend simple patterns*
R23	Recognise line symmetry	Recognise rotational symmetry

Competences of pupils estimated to be classified grade 7

Two criteria at Foundation Level were attained by over 80% of pupils estimated to be awarded grade 7.

R20 Continue patterns

R23 Recognise rotational symmetry

These two were also the only criteria which were extended to General Level for most students.

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Completing a task

Only one Foundation Level criterion was offered to pupils for Completing a task. The General Level criterion marked with an asterisk was not available to most students estimated to attain grade 7 and was omitted from the analysis.

Figure 4.9 Percentage of pupils successful in the classroom (Completing a task)

Foundation Level criterion

	Grades		
Class	5	6	7
R7	82	63	62

	Foundation	General
R7	Explain solution with reference to specific values	Explain solution in general terms*

Competences of pupils estimated to be classified grade 7

No criteria in this section were attained by over 80% of pupils estimated to be classified as grade 7.

Low attainers in the classroom

What can pupils who are estimated to fail to attain grade 6 do in the classroom?

A summary of the competences demonstrated by pupils estimated to be classified as grade 7 in class work is shown under the eight headings used in the preceding anaiysis. These are the criteria which more than 80% of pupils were able to achieve in the classroom. There are no General Level criteria in this list, but an additional list has been compiled showing which General Level competences were attained by more than half of the lowest attaining pupils.

Grade Competences
(criteria attained by over 80% of pupils in the classroom)

Foundation Level

Number

- K27 Calculate using 4 rules with whole numbers and decimals
- K28 Calculate simple % of quantities

Measure

- K18 Calculate perimeter of rectilinear figures
- K19 Calculate area of rectangle, square or right angled triangle

Relationships

- None

Shape

- K13 Plot co-ordinates in first quadrant

Information Handling

- K1 Extract information from simple tables with 2/3 categories
- K2 Interpret graphs with straightforward scales
- K3 Interpret pie charts identifying largest and smallest sectors
- K10 Complete graphs given the structure and the scale in words
- K12 Complete a table

Interpreting a task

- R1 Interpret a problem using 2/3 sources (statements or diagrams)

Doing a task

- R20 Continue simple patterns
- R23 Recognise simple symmetrical figures with line symmetry

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General Level

No General Level criteria were attained by over 80% of our classroom sample. However, a list of General Level criteria attained by over 50% of pupils estimated at grade 7 has been compiled.

Measure

- K18 Calculate the circumference of a circle
- K19 Calculate the area of a kite, parallelogram, rhombus or circle

Information Handling

- K3 Interpret pie charts using proportion of sectors
- K10 Construct graphs when the scale is not given

It is worth noting that the Foundation Level equivalent of each of these General Level criteria is in the list of grade competences. If teachers are seeking to extend the opportunities offered to low attaining students, then moving on to the next level of the other criteria in the grade competences list might be the place to start. These cover all the categories of mathematics used in this report apart from Relationships and Completing a task. Opportunities to develop these latter categories were very rarely offered to low attaining pupils.

5 Points for Discussion

Patterns of results

Both in the examination results for each group of criteria and in the classwork there is, in most cases, a distinctly similar pattern of results. As the grade level awarded to the candidates in mathematics falls so does the number of candidates being successful in any single criterion. The relative difficulty of individual criteria within the group also remains fairly static. If pupils awarded a grade 4 find one criterion more difficult than another (as indicated by the numbers who are successful), then pupils at grades 3, 5, 6 and 7 are also likely to find that criterion relatively difficult. The peaks and troughs of the graphs shown in Chapters Three and Four are remarkably consistent in this regard.

Where there were criteria which were available in both 1991 and 1992, the same patterns held within each year. However, the patterns between the years were less consistent. In about 10% of cases individual criteria behaved erratically with considerable differences in the numbers of candidates being successful on tasks which had been judged to involve the same criterion. Examples of some of these criteria are explored further below and have implications for both teachers and the Examination Board.

How easy is it for teachers and examiners to interpret the EGRC so that questions based on the same criterion give rise to a consistent pattern of results?

Classroom concerns

Analysis of texts

In order for researchers to prepare a profile of competences for each pupil based on the work carried out in class, an analysis of the various textbooks in use was necessary. Our analysis had to be in terms of the statements of criteria contained in the profile and was therefore much more detailed than would normally be expected. However, it did highlight the difficulty of preparing a course for pupils which provided a balanced coverage of EGRC across the elements.

Teachers use a wide diversity of textbooks, most of which are not specially written for Standard Grade mathematics. If they plan their course and analyse their texts in content terms as is suggested in the *Standard Grade Revised Arrangements in Mathematics* this will be helpful in relation to the EGRC of Knowledge and Understanding where the match between content and EGRC is relatively straightforward. However, it is of little help in trying to identify those sections of the texts

which reflect the requirements of the EGRC for Reasoning and Applications.

To what extent would it be useful to analyse texts in terms of EGRC? Are there available texts which allow teachers to move flexibly between Foundation and General Level criteria?

Extending opportunities for low attaining pupils

Several of the classes which we visited provided a fairly restricted mathematics curriculum for their pupils. During our analysis of what low attaining pupils can do we identified a number of criteria at Foundation Level at which over 80% of low attaining pupils were competent. These were as follows

Number

- K27 Calculate using 4 rules with whole numbers and decimals
- K28 Calculate simple % of quantities

Measure

- K18 Calculate perimeter of rectilinear figures
- K19 Calculate area of rectangle, square or right angled triangle

Shape

- K13 Plot co-ordinates in first quadrant

Information Handling

- K1 Extract information from simple tables with 2/3 categories
- K2 Interpret graphs with straightforward scales
- K3 Interpret pie charts identifying largest and smallest sectors
- K10 Complete graphs given the structure and the scale in words
- K12 Complete a table

Interpreting the task

- R1 Interpret a problem using 2/3 sources

Doing the task

- R20 Continue simple patterns
- R23 Recognise simple symmetrical figures with line symmetry

If teachers wanted to extend the opportunities they offered their pupils, then starting with the General Level equivalences of these Foundation Level criteria might be worthwhile. The criteria cover all categories except that of Relationships.

What are the advantages and disadvantages of widening the range of opportunities for low attaining pupils? How helpful is the above list in deciding where to start?

Supporting low attainers in the classroom

Many mathematics departments keep the number of pupils in their low attaining classes at a minimum and also restrict the mathematics curriculum. This means that the class teacher is able to provide a great deal of individual teaching in a narrow range of skills. The line between support and spoon-feeding is not easy to define and was a concern of some of the teachers we visited. The teachers in our sample tended to underestimate the grade level awards of their students. Was this because they believed their pupils would be unable to perform once teacher support was withdrawn?

Are some teaching methodologies more successful with low attaining pupils than others? Can teachers be given some guidance on how to withdraw support gradually?

Boosting the performance of border line pupils

In Standard Grade mathematics the most commonly attained grade is grade 5. It seems to be difficult for pupils to get over the hurdle of moving from a Foundation Level grade 5 to a General Level grade 4. During our study we looked specifically at this border line to try and identify those criteria which discriminated well between the two levels. The full list of those which discriminated best over the 1991 and 1992 examinations are listed at the end of Chapter Three. The criteria mostly focus on the use of symbols and making generalisations. If teachers were seeking to boost the performance of their pupils it might be worth focusing on those particular criteria. Success would of course depend on extending the opportunities to include these criteria for more pupils than seems to be the case at present.

How can teachers help to boost the grades of their pupils so that more of them reach a grade 4? How can low attaining pupils be successfully introduced to abstract concepts? At what stage should this start?

Examination concerns

Interpreting the criteria

Setters who prepare questions for the mathematics examination use the EGRC as a blueprint. They set questions which are designed to assess a range of EGRC and considerable time and effort are expended to minimise differences of interpretation.

The great majority of profiles in this report which illustrate the performance of pupils at different grade levels on individual criteria show patterns over the two years which are fairly consistent. However, there are occasions when one criterion appears to behave in a manner which goes against the trend of the other criteria in the group and provides quite different results from year to year.

There are a number of reasons why examination questions may be difficult which have nothing to do with the intrinsic difficulty of the criterion. The language used is ambiguous or unfamiliar, the question depends on the results of an earlier question which has not been completed successfully, the question is at the end of a paper and the pupils run out of time, the question is set in a context which is unfamiliar or the question depends on an unusual application.

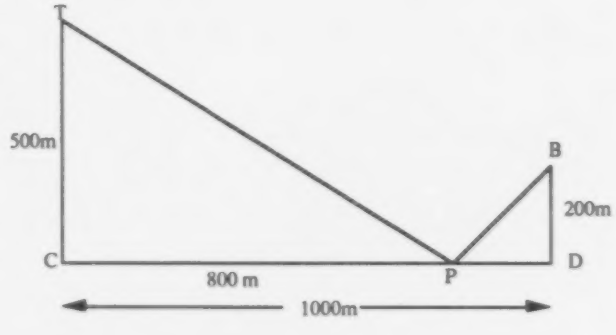
To take one example, the criterion K16 which relates to the Theorem of Pythagoras, behaved more or less as one might expect in 1991 with more than 80% of grade 3 pupils being successful and the number of successful pupils falling as the grade level fell. However, in 1992, less than 20% of grade 3 students were successful and fewer pupils at all grades could attain the criterion, despite it being a very routine procedure.

In both years the questions were part of Paper II at General Level i.e. they were designed to be applications of the Theorem of Pythagoras.

1991

The diagram shows one possible position of P, 800 metres from C.

Calculate the total length of the new gas pipes (TP and PB) for this position of P.



1992

Fiona has bought a 1000 piece jigsaw puzzle.

On the side of the box, it says that the completed jigsaw is a rectangle measuring 26 inches by 21 inches.

Fiona has a circular table which has a diameter of 32 inches.

Will the completed jigsaw fit onto the table?

The first question includes a drawing of a right angled triangle with measurements marked on the sides. Apart from having to do a subtraction

to find the length of PD, the question is set out in a form which will be recognisable to most pupils as requiring the Theorem of Pythagoras.

The second question contains excess information in its first line. We do not need to know, nor will we use the fact that the jigsaw has 1000 pieces. The dimensions are not attached to the diagram (which is more of a picture than a mathematical diagram) There are no diagonal lines on the picture as a hint. It is doubtful if the first mathematical solution that comes to mind involves the Theorem of Pythagoras. Many pupils could not show whether or not they were able to use Pythagoras because they could not even get started.

Both questions were, of course, assessing more than just straightforward knowledge. However, the second question raised many more complexities than the first. Changes in the format of the Standard Grade Mathematics examination which take effect from this year (1993) may, at least in part, minimise this type of difficulty. Questions on Knowledge and Understanding and Reasoning and Applications will no longer be presented in separate papers. Questions will be a combination of knowledge and the application of that knowledge. Pupils will, therefore, be given a lead into the problem. However, the message for teachers seems to be that they need to spend time not only teaching routine procedures but looking at a variety of applications of these procedures.

*Do pupils know **when** to do a routine as well as **how** to do it? Are they given sufficient practice in applying knowledge?*

Changes to the grade related criteria

At the start of this study agreement was reached with the mathematics working party that the framework for analysis would be based on the EGRC since that was familiar to teachers. However, many of the EGRC as stated in the Standard Grade Arrangements were sub-divided into separate criteria on the assumption that the component parts would behave differently. This proved to be the case. For example, one of the EGRC from Knowledge & Understanding at General Level reads 'use the properties of shape to calculate angles, lengths, areas and volumes'. Two components from within that group (Calculate the circumference of a circle, Solve right angled triangles using trigonometric ratios) are among a small number of criteria which have been identified as discriminating consistently between grade 5 and grade 4 performances. Another of our criteria (Evaluate formulae in symbols) forms one component of an EGRC which includes calculations in number, money and measure. Again it behaves quite differently from the rest of that group, being consistently more difficult for many pupils and again discriminating well between grades 4 and 5 .

Each EGRC contains a variety of component parts. Do the separate parts behave in the same way? Could they be re-grouped to form more consistent patterns of behaviour?

Links with Mathematics 5-14

When seeking to group our various sub-divisions of the EGRC into manageable categories, it seemed most useful to arrange them according to information contained in the document *Mathematics 5-14*. Our decisions on how the two systems meshed together were based on a thorough scrutiny of the text. However, if time had allowed it would have been interesting to carry out a more in-depth analysis to find out how well the criteria do fit these categories.

Teachers working at the lower stages of the secondary are already conversant with the outcomes and strands of the 5-14 document and will be looking for links between what happens at S1/S2 and the Standard Grade course at S3/S4. It would be a great waste of effort if teachers were left to carry out this task for themselves. Some of our work in this study may be helpful in this respect.

How can the links between Standard Grade and the 5-14 programme be made clear to all teachers?

Different purposes of assessment

The EGRC which were devised by a joint working party of mathematics specialists are used by setters when preparing examination questions. They are not used directly to grade the pupils' responses. The present marking system which uses cut-off scores when determining the grades for each element, makes it easy to provide aggregate grades. It also makes it possible for a number of pupils to be awarded the same grade for quite different patterns of behaviour. It is not possible to define a grade 4 candidate in terms of EGRC attained.

In this study, because we were interested to discover what pupils could do in examinations, a more direct criterion-referenced assessment system had to be used. Each question was analysed to determine where it fitted into our framework of competences and each response was assessed on a simple 'can/cannot do' basis. This enabled us to look in detail at the performance of pupils across the ability range on individual components of the profile. It would not have been easy to arrive at an overall award for each pupil.

Which of these systems is of most use to teachers? The Examination Board's purpose in assessing pupils is to provide a summative grade for attainment at the end of a two year course in mathematics. Our purpose was to describe what pupils can (and cannot) do in relation to detailed aspects of mathematics. We would suggest that this latter purpose better reflects the needs of teachers. In order to improve teaching and learning teachers need to know the strengths and weaknesses of their pupils.

To what extent can teachers use a direct grading system to provide them with the information they need to improve teaching and learning?

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Criteria Descriptors used in analysis of Standard Grade Mathematics

Knowledge and Understanding

Appendix 1

Code	Category	Foundation	General	Credit
K1	Info Handling	Simple tables-2/3 categories of data (timetables, ready reckoners,) * †	Tables with up to 5 categories of data	Extract information from mathematical diagrams. * †
K2	Info Handling	Graphs with straightforward scales †	Graphs unnumbered divisions, interpolations, cumulative, combined * †	Graphs with misleading scales. * †
K3	Info Handling	Piechart (largest/smallest sector) †	Piechart (proportion of sectors) *	Piechart - novel
K4	Measure	Interpret scale drawings with scales expressed in words; * †	Interpret scale drawings with scales as ratio, RF or scaled line * †	Nothing at this level
K5	Relationships	Identify trend in a line graph where there is one main trend * †	Identify changes of features in graphs †	Effect of a change of variable; inverse variation. †
K6	Relationships	Nothing at this level	Know that y = ax + b is the equation of a straight line	Know graph of y=mx+c gradient m, intercept c and v.v. * †
K7	Number	Instruments with straightforward scales * †	Able to interpolate * †	Nothing at this level
K8	Number	Nothing at this level	Read negative numbers on scales, coordinates *	Nothing at this level
K9	Shape	Cube, cuboid, * †	Complex shapes, pyramid, cylinder, triangular prism *	Nothing at this level
K10	Info Handling	Construct graphs given the scale (in words) and the structure; *	Construct graphs, scale not given * †	Trigonometric graphs. †
K11	Measure	Construct scale drawings with scales expressed in words;	Construct scale drawings , scale may not be given * †	Nothing at this level
K12	Info Handling	Complete a table	Nothing at this level	Nothing at this level
K13	Shape	Plot/determine co-ordinates in first quadrant †	Plot/determine coordinates in all four quadrants	Nothing at this level
K14	Relationships	Nothing at this level	Construct formulae in symbols to describe a given relationship * †	Construct formula to describe relationship expressed graphically
K15	Shape	Calculate third angle of triangle; * †	Solve right angled triangles using sine cosine tangent * †	Solve scalene triangles using sin, cosine, tangent. * †
K16	Shape	Nothing at this level	Use Theorem of Pythagoras * †	Nothing at this level
K17	Shape	Angles (supplementary/revolution) *	Angles in a circle * †	Angles/tangent/periodicity *

*Criteria in 1991 examination papers. †Criteria in 1992 examination papers.

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Criteria Descriptors used in analysis of Standard Grade Mathematics

K18	Measure	Perimeter of rectilinear figures; †	Circumference of circle * †	Arc of circle †
K19	Measure	Area of rectangle, square and right angled triangle; *	Area of triangle , kite, parallelogram, rhombus, composite figures and circle * †	Area of circle *
K20	Measure	Nothing at this level	Surface area of cube cuboid, cylinder, triangular prism	Surface area of composite solid.
K21	Measure	Volume of cube and cuboid * †	Volume of cylinder, triangular prism * †	Composite solid * †
K22	Number	Select operation * †	Nothing at this level	Select steps for routines eg joint variation, ax+by; depreciation. * †
K23	Number	Selects steps for direct proportion problems * †	Inverse proportion †	Steps for inverse proportion (square) *
K24	Relationships	Nothing at this level	Simple equations with non-negative solutions * †	Quadratic equations * †
K25	Relationships	Nothing at this level	Nothing at this level	Simultaneous equations * †
K26	Relationships	Nothing at this level	Simple inequations with coefficients as a member of N	Inequations * †
K27	Number	Four rules with whole numbers and decimals; * †	Add and subtract integers mainly in practical contexts * †	Surds, fractions, real numbers, division of scientific notation. *
K28	Number	Calculate simple % of quantities; * †	Express one quantity as a percentage of another *	Cumulative %/compound interest * †
K29	Number	Money calculations (income, savings, wages, expenditure, bills, HP, prof/loss, discount, VAT) * †	Money calculations (simple interest on fractions of year, exchange rates, premiums) †	Depreciation/appreciation
K30	Number	Round to the nearest unit (or penny) * †	Round to required number of DP *	Significant figures * †
K31	Relationships	Evaluate formulae expressed in words * †	Evaluate formulae given in symbols * †	Evaluate formulae with indices * †
K32	Info Handling	Averages * †	Nothing at this level	Nothing at this level
K33	Number	Duration of time * †	Nothing at this level	Nothing at this level

K34	Relationships	Nothing at this level	Collect terms, remove brackets, find common factor * †	Expressions of the form f(x)/g(x) * †
K36	Number	Approximations of calculations using rounding	Approx of calculations using rounding (4 rules)	
K37	Number	Rough metric/imperial equivalents	Rough metric/imperial equivalents	
K38	Number	Convert within units (metric length, weight) * †	Convert within units (area, capacity) * †	
K39	Number	Nothing at this level	Standard notation * †	Standard notation/law of indices * †

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Criteria Descriptors used in analysis of Standard Grade Mathematics

Reasoning and Applications

Code	Category	Foundation	General	Credit
R1	Interpret	2/3 sources (straightforward related statements and/or diagrams) * †	Contexts involving excess information * †	Contexts involving excess information * †
R2	Complete	Interpret solution in context of problem †	Interpret intersection of 2 graphs (or solution) in the context of the problem *	Interpret solution in the context of the problem *
R3	Complete	Reject results which do not make sense †	Reject inappropriate results * †	Reject invalid solutions *
R4	Interpret	Nothing at this level	A simple equation * †	Equation * †
R5	Interpret	Nothing at this level	A simple inequality	Polynomial, exponential or trigonometric function.
R6	Interpret	Create, with guidance, formulae in words to describe a relationship	Simple relationship expressed in symbols (relationship not given) * †	Relationship expressed in symbols * †
R7	Complete	Explain solution with reference to specific values * †	In general terms, displaying an awareness of the different stages * †	Explain solution * †
R8	Complete	Nothing at this level	Set out the solution so that the reader can follow the steps *	Explain clearly/highlight importance/logical thought *
R9	Interpret	Nothing at this level	Nothing at this level	Combine information/draw inferences *
R10	Do	Nothing at this level	Prove/disprove conjecture	Prove/disprove conjecture *
R11	Do	Experiment	Experiment in an informed way	Try special cases *
R14	Do	Model/draw the situation *	Nothing at this level	Nothing at this level
R15	Do	Produce an organised list (given some find others) * †	Produce an organised list (find all) * †	Nothing at this level
R16	Do	Look for a pattern *	Nothing at this level	Nothing at this level
R17	Do	Guess-check-improve †	Nothing at this level	Nothing at this level
R18	Do	Make a conjecture and test with particular examples	Nothing at this level	Nothing at this level
R19	Do	Work backwards	Nothing at this level	Nothing at this level
R20	Do	Continue simple patterns * †	Continue patterns * †	Continue complex patterns *
R21	Do	Extend simple number patterns *	Extend simple patterns †	Extend complex patterns

R22	Do	Nothing at this level	Generalise features of patterns * †	Use symbols to make a conjecture about the general pattern. *
R23	Do	Recognise symmetrical figures with simple line symmetry	Recognise shapes with line and rotational symmetry * †	Nothing at this level
R24	Interpret	Make simple deductions from 2 or 3 given facts * †	Make deductions from facts which may have to be identified	Make deductions/introduce symbols * †
R25	Interpret	Decide the steps (2/3) and their order (non-routine problems) * †	Decide the steps and their order (4 or 5) non-routine problems) †	Decide the steps * †
R26	Interpret	Nothing at this level	Take a systematic approach	Take an efficient approach

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